PERIODICAL ROOM
GENERAL LIBRARY
UNIV. OF MICH.

JAN 5 1934

THE FEBRUARY SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

THE SIGNIFICANCE OF THE EMOTIONAL LEVEL. PROFESSOR WALTER B. CANNON 101
WHAT IS A FIFTY-POUND WEIGHT? RALPH W. SMITH 111
SCIENTIFIC METHODS OF OYSTER FARMING. DR. HERBERT F. PRYTHERCH 118
HOW RIVERS CUT GATEWAYS THROUGH MOUNTAINS. PROFESSOR DOUGLAS JOHNSON 129
THE CHACHAS OF ST. THOMAS. DR. EARL B. SHAW 136
THE INTERNATIONAL STATUS AND OBLIGATIONS OF SCIENCE. PROFESSOR A. V. HILL 146
SOCIAL STRATIFICATION IN A SMALL COMMUNITY. DR. EARL H. BELL 157
CONSERVATION OF GAME OR OF WILD LIFE—WHICH? W. L. MCATEE 165
SCIENCE SERVICE RADIO TALKS:
HOW ANIMALS SPEND THE WINTER. AUSTIN H. CLARK 170
APPLIED GEOGRAPHY. DR. ISAIAH BOWMAN 173
DANGER SIGNALS IN CANCER OF THE STOMACH. DR. WALTER C. ALVAREZ 177
THE VALUE OF INSECTS TO THE CALIFORNIA INDIANS. PROFESSOR E. O. ESSIG 181
THE PROGRESS OF SCIENCE:
Edward Lee Thorndike: President of the American Association for the Advancement of Science; The Boston Meeting of the American Association for the Advancement of Science; The Fels Planetarium of the Franklin Institute 187

THE SCIENCE PRESS
LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

Yearly Subscription $5.00 Single Copies 50 cents

NEW BOOKS OF SCIENTIFIC INTEREST

An Introductory Course of Mechanics. E. G. PHILLIPS. viii + 255 pp. $3.25. Cambridge University.

In this book on elementary mechanics the author regards the subject throughout as a branch of mathematics, and not as ancillary to physics or engineering. Free use is made of the calculus, and prominence is given to vector methods.

A Text-Book on Heat. A. W. BARTON. xiii + 378 pp. Illustrated. $2.75. Longmans, Green.

This text-book has been written to satisfy the needs of students reading for university entrance examinations in England. It covers investigations which have been made in the realm of heat and the theories which have been put forward to account for them.

The Autogiro and How to Fly It. REGINALD BRIE. ix + 82 pp. Illustrated. $1.75. Pitman.

A simple explanation of the methods of handling the autogiro in the air and on the ground. A chapter on "Theoretical Considerations" is added at the end. A foreword by the inventor of the autogiro, Juan de la Cierva, is included.

The Drama of Weather. SIR NAPIER SHAW. xiv + 269 pp. Illustrated $3.50. Macmillan.

The author, sometime president of the International Meteorological Committee, presents a series of unconventional essays dealing with all phases of meteorological phenomena. Discussions of recording instruments and weather-maps are included, as well as a brief appendix.

An Introduction to the Study of Fossils. HERVEY WOODBURN SHIMER. Revised edition. xvii + 496 pp. Illustrated. $4.00. Macmillan.

This introduction to the study of paleontology is intended to awaken interest in fossils as once living animals and plants. The fossils are interpreted through the structure, physiology and ecology of related living forms.

The Life of a Fossil Hunter. CHARLES H. STERNBERG. xiii + 286 pp. Illustrated. Jensen Printing Company.

The narrative of the adventures of the oldest living fossil hunter, telling of his expeditions throughout the western United States. In the introduction, Henry Fairfield Osborn pays tribute to the contributions of the author to the science of paleontology.

Our Stone-Pelted Planet. H. H. NININGER. xxv + 237 pp. Illustrated. $3.00. Houghton Mifflin.

A book about meteors and meteorites written in non-technical language, telling of their origin, composition and especially of their "falls." An appendix of a hundred pages lists the meteorites of the world.

Food Products. HENRY C. SHERMAN. xii + 674 pp. Illustrated. $3.00. Macmillan.

The author endeavors to present the present-day view of food products in their economic, nutritional, sanitary and technological aspects. He is the recent recipient of the William H. Nichols Medal of the American Chemical Society.

Health Facts for College Students. MAUDE L. ETHELREDGE. 342 pp. Illustrated. $2.00. Saunders.

A text-book of individual and community health, presenting a simple discussion of common problems in hygiene. The author suggests certain principles to be followed by students in working out their particular problems.

The California Deserts. EDMUND C. JAEGER. x + 207 pp. Illustrated. $2.00. Stanford University.

A handbook of the Colorado and Mohave Deserts covering the history of the desert, physiographic and climatic features, flora and fauna and the aborigines. Pen-and-ink drawings depict desert scenes and the plants and animals.

Heredity and Environment. GLADYS C. SCHWESINGER. viii + 484 pp. $4.00. Macmillan.

An attempt to appraise the present status of knowledge in the field of eugenic research, forming a reference work on psychological measurement and a summary of studies on the developmental origins of mental characteristics.

Inventions, Patents and Trade-Marks. MILTON WRIGHT. Second edition. xii + 310 pp. $2.50. McGraw-Hill.

A manual of practical information on the protection and promotion of inventions and their original devices. It tells the manufacturer and the merchant, as well as the inventor, how to go about getting and keeping exclusive rights to his property.

New Introductory Lectures to Psycho-Analysis. SIGMUND FREUD. xi + 257 pp. $3.00. Norton.

After a silence of fifteen years the author discusses subjects such as dreams, the occult, anxiety, the psychology of women, ending with a chapter on the philosophy of life. The work is addressed as much to the layman as to the specialist.

Autobiography of a Bird-Lover. FRANK M. CHAPMAN. xiii + 420 pp. Illustrated. $3.75. Appleton-Century.

The story of an ornithologist's career, the success he achieved in his chosen field, his travels in many lands in pursuit of knowledge about birds, their habits, habitats, evolution and their importance to the spiritual life of man.

THE SCIENTIFIC MONTHLY

FEBRUARY, 1934

THE SIGNIFICANCE OF THE EMOTIONAL LEVEL

By Dr. WALTER B. CANNON

GEORGE HIGGINSON PROFESSOR OF PHYSIOLOGY, HARVARD MEDICAL SCHOOL

An emotion, as the word implies, is a condition that moves us. Indeed, when we have an experience pervaded by a powerful emotional element we speak of it as a *moving* experience. The force which is exhibited when a strong emotion seizes upon us may be so dominant as to sweep away all considerations of prudence. The mystery of this force has long roused the interest of philosophers and biologists. Spinoza and Descartes have discussed its nature, and Darwin and others have studied its manifestations. Modern researches have added considerably to our knowledge of its sources and its effects. I propose that we consider together some recent evidence as to the physiological nature of emotional excitement.

In order that we may be quite specific in our examination of the evidence, I suggest that we select at first a single emotion—that of rage—and study its characteristics. In a physiological sense an exhibition of rage follows what may be called a "reaction pattern." When we see a man who is enraged we note his crouching body, his frowning brow and his lips drawn close over clenched teeth as he growls his threats. His fists are tightened or are grasping a seized weapon. These, however, are the superficial aspects of the pattern. An examination of the deeper changes would reveal an acceleration of the heart beat, a rise of blood pressure, an increase of blood sugar, a redistribution of blood in the body, a greater output of adrenal secretion and a digestive process that is inhibited. Some of these changes can be directly observed in man; and others are inferred from their relations in lower animals.

It is typical of these features of the pattern response of rage that they have many of the characteristics of reflexes. First of all, we *do not learn* to be enraged; like laughing and weeping, the rage reaction is seen soon after birth as a mode of behavior fully prepared for display. Again, like a reflex, it has a *definite stimulus;* just as tickling will evoke laughter, so anything that hampers or checks or thwarts the satisfaction of any strong impulse in us will call forth the rage response. Like a reflex, also, the reaction of rage is *prompt* when the stimulus is appropriate. And it is *permanent;* the typical pattern will be evoked at different ages in the same individual when the appropriate conditions are present. Furthermore, it has a *constant* and fairly *uniform* manifestation in different races; one may not understand the language in a foreign country, but on sight one can readily understand the attitude of an enraged native. Again, it is characteristic of reflexes that they are *useful*—sneezing and coughing, for example, reflexly clear the

respiratory passages of irritating material. Similarly, the changes which occur in rage, especially the deep changes I have referred to above, can be reasonably interpreted as adaptations of the organs of the body such as to render the individual more effective in the struggle which is likely to accompany the aggressive attitude that is associated with rage. Thus, the faster heart rate and the higher blood pressure hasten the transport of the larger quantity of oxygen needed for increased activity and the larger quantity of carbon dioxide resulting from the oxidized metabolites; and the increase of blood sugar provides fuel for laboring muscles. The other changes, likewise, fit into this picture. Finally, it is a fact of primary importance that the *expressions* of emotions in man and lower animals, as Darwin pointed out in his classical volume, are *similar*. When the hungry dog is enraged, by thwarting, for example, his instinctive act of eating, he, like the angry man, shows his teeth and growls and manifests the deep visceral changes already mentioned. Such, then, are some of the characteristics of the reaction of rage.

When we compare the nervous system of man and lower animals the most striking difference is to be found in the relatively enormous development of the cerebral hemispheres, with their much folded cortical layers, in man as compared with any other vertebrate form. These great masses of nervous tissue, developed from the anterior portion of the brain stem, are new and special features in the human being, sharply differentiating him from all other related fellow-creatures. The spinal cord and the brain stem, on the other hand, are much less altered. Indeed, they can be regarded in their general aspects as practically common to man and to other higher vertebrates.

That the reactions of the two parts of the nervous system which I have just mentioned are strikingly different from one another is well known. The responses of the spinal cord and the brain stem, when a stimulus is applied, are routinely prompt, uniform and stereotyped. The patellar and pupillary reflexes are examples. Indeed, it is in these lower parts of the nervous system that reflexes, simple and complex, have their central stations. The reactions which involve the cortex of the cerebral hemispheres, on the other hand, instead of being prompt are delayed—there may be an indefinitely long interval between the reception of the stimulus and any behavior precisely related to it. Also, instead of being uniform, these cortical reactions are unpredictable; the same situation presented to different individuals may call forth extraordinarily different activities. And finally, instead of being stereotyped, these reactions are rather easily modifiable; in fact, the whole process of education is directed toward modifying the attitudes and activities of individuals on the basis of previous social experience. We see, then, that there is a sharp separation between the fixity and monotony of the responses from the spinal cord and the ancient portion of the brain, and the uncertainty and variety of the responses from the much more complex cerebral hemispheres.

The question now arises as to where the neurone patterns lie which express emotional excitement. Are they stationed in the primitive portion of the nervous system or in that portion which has been so highly developed in the human being? Evidence in answer to this question was obtained some years ago by Britton and myself in experiments on the cat, in which, immediately after etherization, we rapidly destroyed the cerebral cortex (which subserves consciousness), and then permitted the remnant of the animal to emerge from the anesthetic. Almost as soon as freed from anesthesia the preparation exhibited an extraordinary group of phenom-

ena which we called "sham rage." The hairs stood on end so that the tail was like a bottle brush. The pupils were widely dilated, sweat poured out on the toe pads, the blood pressure rose to 200 mm of mercury or higher, the heart rate went up from a normal of approximately 120 beats per minute to 250 or even 300 beats, and the blood sugar mounted until at the end of two hours it might be five times the usual concentration. Here you will note a manifestation of the deeper changes occurring in the rage pattern, but, I would emphasize, in the absence of any possible functioning of the cerebral cortex. Later my colleague, Bard, studied this preparation still further and learned that it was possible to remove both cerebral cortices, the corpus striatum and, indeed, all the brain anterior to the lower posterior portion of the diencephalon without disappearance of the sham-rage phenomena. When he removed this small portion, however—a bit of tissue in the cat hardly larger than the tip of the little finger—the phenomena entirely vanished and were replaced by decerebrate rigidity. It appeared clear that the neural mechanism for the display of the pattern of rage is located, in the cat, in the hypothalamus. For present purposes, it is sufficiently accurate to speak of this region as the thalamic region. It is here that we find what we shall call the "emotional level."

This location of the neurone pattern which manages the bodily exhibition of the rage response has important significance in explaining many of the phenomena not only of rage but of other emotions as well, and also certain conditions which are not emotional in character. Let us survey together these variously important bearings of the emotional level on other parts of the organism, and in relation to facts already considered.

In the first place, it is obvious that the presence of the neural arrangement for the reaction of rage in the thalamic region, where ocular and other reflexes have their seat, is consistent with the facts already stated which show that the bodily manifestations of rage have the typical features of simple reflexes. It has those characteristics because it is managed in that part of the brain in which the reflex type of activity is natural and inherent.

In the second place, the locus of the center for the rage response in the thalamic region explains why the expression of rage has many features that are common to man and to lower animals —why both snarl and show their teeth. The thalamic region is in the ancient brain stem which has undergone relatively little change in the course of vertebrate evolution, and therefore its structure and function have not been greatly altered in the development from lower mammals to human beings. Because the brain stem is similar in higher vertebrates the responses from it are similar.

A third significant fact is found in the appearance of the characteristic posture and features of rage after the cortex has been removed. Evidently, this fact proves that there is a double control of certain of the peripheral effectors from two levels—from the cortex and from the thalamic region. When the cortex is removed, voluntary control is abolished but control from the emotional level is still retained. We see illustrations of this in the primary stage of ether anesthesia or when nitrous oxide is used as an anesthetic. Under these conditions the individual may be regarded as chemically decorticated. Voluntary control is abolished, but the emotional level is still active. The patient under light ether may show signs of rage by fighting and muttering at the attendants who attempt to restrain his movements, and the patient under nitrous oxide may have expressions from the emotional level in laughter or tears, for the anesthetists say that

laughing gas might quite as reasonably be called weeping gas. Again, in cases of hemiplegia the patient may have destruction of the motor cortex or interruption of the subcortical motor pathway on one side with attendant abolition of voluntary control of facial muscles. Tell such a patient a funny story, however, or make him sad, and he will appropriately laugh or cry, with bilateral symmetry of the response on the two sides of the face. On the other hand, there may be damage of the structures on one side in the thalamic region; then the patient has symmetrical control of the facial muscles if they are voluntarily innervated, but an appeal to the emotional level results, for example, in a one-sided smiling or weeping. Most interesting of all, in relation to the studies on experimental animals, are those human cases of pseudo-bulbar palsy in which cortical control of the thalamic region is largely abolished. In such cases the emotional expression may be indefinitely prolonged. There are records of patients who have wept or laughed for hours without stopping. In one such instance laughter started at 10 o'clock in the morning and continued steadily till 2 o'clock in the afternoon! It may be noted that these signs of sadness or hilarity are without any reference to the actual situation.

In connection with the evidence that the removal of cortical influence, either mechanically by operation, or chemically by anesthetics, or pathologically by disease, releases the emotional level and allows it to manifest its functions to a supreme degree, there is an interesting consideration regarding sleep. It appears logical to suppose that sleep could not possibly be a simple subsidence or abolition of the functions of cerebral cortex. If that were the case we should expect sleep to be attended by a rather elaborate exhibition of emotional reactions. Instead, of course, it is a period of lessened activity throughout the organism. Since the diencephalon is a region in which many bodily activities have their seat and which in the absence of cortical government occasions an extraordinary exaggeration of these activities, the conclusion would seem to be rational that sleep might have its source in some change in the diencephalon. The interesting experiments of Hess, in Zurich, which show that stimulation of certain areas in this region causes animals promptly to become somnolent and lie down to rest and slumber, offer strong support for this suggestion.

In relation to the double control of lower motor neurones from the two levels—the cortical and the thalamic—previously noted, there is an important distinction to be made between the control of skeletal or facial muscles and the viscera. Whereas facial muscles, for example, are controlled from both regions, so that there may be both voluntary and emotional expression, the viscera are controlled only from the emotional level. It should be obvious that although, in the presence of emotion-provoking circumstances, the cortex by voluntary act may set the features in a state of calm or indifference, the absence of ability of the cortex to affect directly the visceral portion of the thalamic pattern would not permit the palpitating heart, the high blood pressure or the active sweat glands to be inhibited. Thus a person may put on a bold face because cortical government of the facial muscles can at times dominate the emotional government of these muscles, but he may be boiling inside because the cortex can not govern the organs of the thorax and the abdomen.

Another consideration which has an importance, especially for psychology, is the evidence which points to the thalamic region as the origin of that special quality—the "affect" or "feeling tone" associated with sensation—which changes the "object-simply-perceived," as William James framed it, into the "object-

emotionally-felt." The testimony that the source of the peculiar experience of emotion is found in the diencephalon is derived chiefly from clinical observations on patients who present the so-called "thalamic syndrome." Such patients, as Henry Head has noted, may have abolition of cortical control of the thalamic region on one side. In these circumstances the phenomena which result can be best explained as an exaggerated activity of the thalamus on the side of the lesion. Associated with this greater activity is a very striking intensification of feeling tone or emotional experience, but only on the affected side. On that side, contact with a cold test-tube is felt as something extremely disagreeable. On the other hand, contact with a warm test-tube yields exquisite delight. A pin-prick, felt as a slightly unpleasant sensation on the normal side, is reported, when tried on the other side, as being absurdly painful. And even if there is a central source of elation, as, for example, when martial music is played, the effect again is unilaterally exaggerated.

The points just detailed, taken in relation to previous evidence, have an important bearing on a well-known theory of emotion. You are doubtless aware of the suggestions made by William James and Carl Lange which resulted in the so-called "James-Lange theory" of the origin of emotional experiences. In general statement they attributed the emotional elements in consciousness to reverberations from peripheral changes, especially those arising from modified function of the viscera. Does not the recently emphasized rôle of the emotional level offer an alternative explanation? We have seen clear evidence that the thalamic region when excited discharges downwards to skeletal muscle and the viscera, and, as Head's cases prove, it simultaneously discharges upwards to the cortex. If we did not know the rôle of the thalamus as a source of impulses discharged in the two directions, we should naturally suggest, as James and Lange did, that the visceral disturbances are the source of emotional feelings. It is obvious, however, that the James-Lange theory can not account for the striking unilateral intensification of affective tone in the cases of unilateral damage to the cortico-thalamic tract, described by Head. Furthermore, the theory fails to account for the continuance of emotional experience in persons with transection of the cervical cord whose viscera are no longer able to report to the cortex.

Still another interesting point related to the emotional level in the diencephalon is the explanation it offers of the mysterious character of emotional experience. We probably have no conscious states associated directly with the nervous processes occurring in the thalamic territory. Certainly it is true that reflexes in that region, such as those governing the iris and those concerned with body posture, are not attended by consciousness. If we may assume that the pattern reactions of neurones which operate in this region are not immediately associated with conscious states but influence consciousness only when they discharge to the cortex, there would be a reasonable explanation of the mystery. The emotional element would be something added to the perceived object, but added suddenly and intensely from outside the conscious realm. Thus might be explained certain expressions in common use. Persons testify to being "surprised" by an emotional experience, to being "seized" by powerful feelings, to being "possessed." They testify that something "surged up within them" and controlled their actions. All these sayings, which are taken from daily experience, are readily accounted for if we regard the emotional level as being subconscious.

In order to make clear the next matter of significance in the emotional level

—the way in which emotions may profoundly influence the organism—I must first present some basic considerations concerned with our two environments. We are all aware of our external environment, the structure and motions of objects that surround us, which we learn about through our sense organs. By means of these sensitive areas on or near the body surface there are sifted into us impressions of air vibration, contact, chemical change and rays of light which start impulses which are transmitted along nerve paths to the cerebral cortex and there are combined in perceptions of sound, touch, smell or taste, and vision. From the cortex nerve impulses pass down to skeletal muscles. By means of them, we directly or indirectly produce all the varied alterations of our surroundings, such as are seen, for example, in airplanes, ocean liners, radio transmission and the other miracles of present-day civilization. Commonly we regard ourselves as living in this external environment. In fact, however, we are shut off from it by a layer of dead material—the horny covering of the skin or the mucous covering of other parts of the body surface. All that is really alive within us is bathed in a fluid —the rapidly moving blood and the more slowly moving lymph. It is in this "fluid matrix" of the organism that the living parts reside. This constitutes what Claude Bernard called the "internal environment."

Variety may be the spice of life so far as the external environment is concerned, but constancy is of primary importance for the internal environment. Indeed, only by the maintenance of a fair degree of constancy in some of the important constituents of the fluid matrix are we permitted to continue our ordinary existence. For example, the usual concentration of blood sugar is approximately 100 mgm in 100 cc of blood, or 100 mgm per cent.—a heaping teaspoonful for an adult. If the concentration falls to about 45 or 50 mgm per cent., convulsions are likely to arise and a continued fall to a lower level will result in coma and death. Or take calcium as another constituent. If the calcium concentration, which is normally about 10 mgm per cent., is reduced to half that figure convulsions occur, and if it rises to 20 mgm per cent. the blood may become so viscous that only with difficulty may it be made to circulate. Or consider the reaction of the blood. Ordinarily it is slightly alkaline. If it is changed until it becomes even in the least degree acid the individual will go into a coma, and if it is made slightly more alkaline than the normal degree he will go into convulsions. These examples illustrate the somewhat narrow margin of safety which prevails in the fluid matrix; that we are ordinarily free from the dangers of coma or convulsions indicates that there must be nice arrangements for the avoidance of the shifts that would bring upon us the menace of these dangers.

The mechanisms for constancy of the internal environment are to be found in the autonomic or involuntary nervous system. As you are well aware, there are three divisions of this system—the cranial and sacral or parasympathetic divisions, and the sympathetic. It is characteristic of the cranial division that it serves for the conservation of the bodily energies and the laying by of bodily reserves. Thus the vagus, as a part of this division, holds the heart in check when bodily activity is minimal. And the vagus also establishes a tonic state of the gastro-intestinal tract, and in cooperation with other representative nerves of the cranial division stimulates secretion of the digestive glands, when such function is appropriate, so that the food which is taken in is properly digested and utilized or stored for future use.

The sympathetic division consists of a series of ganglia arranged along either

side of the mid-line from the superior cervical ganglion high in the neck to ganglia low in the pelvis that are connected by so-called preganglionic fibers with the thoracic and upper lumbar portions of the spinal cord and that send out postganglionic fibers to smooth muscles and glands in all parts of the body. Smooth muscle thus innervated is found at the roots of hairs, in the walls of blood vessels, in the gastro-intestinal tract and in other viscera. The glands include not only those producing sweat on the skin surface, but also the digestive glands secreting into the alimentary canal.

It is characteristic of the sympathetic division that, when strongly excited, it acts as a whole. This unitary action of the sympathetic is reinforced by a chemical agent, adrenin, which nerves in this division cause to be discharged from the adrenal medulla and which, carried in the blood stream, has practically everywhere in the body the same effects as sympathetic impulses themselves. In this unitary action the sympathetic induces a faster heart beat, a contraction of blood vessels in the splanchnic area and in the skin with consequent rise of blood pressure, a dilation of the blood vessels in skeletal muscles, a contraction of the spleen where red corpuscles are concentrated, an enlargement of the bronchioles, an increase of blood sugar by discharge from stores in the liver, and a faster metabolism. It is a matter of considerable interest that these alterations are serviceable for maintaining constancy of the internal environment in a variety of circumstances which might disturb that constancy.

We can understand most clearly the functions of the sympathetic division if we examine the deficiencies of animals which have been completely deprived of their sympathetic system. By applying surgical methods it is possible to remove both ganglionic chains from such animals as the dog, the cat and the monkey. These animals will live for many months —indeed, some of our cats have lived for years—in the confines of the laboratory without at first sight appearing to be different from quite normal animals. The reason for this deceptive appearance of normality, however, is due to the circumstance that ordinarily the animals are not subjected to any disturbing stress. As soon as such stress is placed upon them they immediately manifest their deficiencies. For example, if they are emotionally excited there is no increase of blood sugar. The facilities for mobilizing this source of energy for muscular work have been destroyed. Again, if they struggle the heart may beat somewhat more rapidly because of lessening of the vagal check, but it can not accelerate as it normally does, because the accelerators in the sympathetic division have been removed. Furthermore, the blood pressure, instead of rising, actually falls in the absence of the sympathetic vasoconstrictor nerves. Also, whereas in the normal animal contraction of the spleen discharges concentrated corpuscles into the circulation and thus increases the carriers of the respiratory gases, this function in the sympathectomized animal is totally abolished. Moreover, the protection against temperature change is much impaired. In the normal animal, such as the cat, there occurs on exposure to cold an erection of hairs which enmeshes a thicker layer of air about the body—a layer which is a poor conductor of heat and which, therefore, protects against heat loss. Besides this change, there is, as in man, a contraction of the surface vessels so that the warm blood of the body is less generously delivered to the skin where it would lose heat to the cool outer atmosphere. In addition, there is a discharge of adrenin which, as mentioned above, accelerates the metabolism of the body and thus produces an extra amount of heat, which helps to prevent the lowering of body temperature. Note that all these changes—the erection of

hairs, constriction of blood vessels and discharge of adrenin—are brought about by the sympathetic system. But this system is not only active when the temperature tends to fall; it is serviceable, likewise, when the temperature tends to rise, for under such conditions it acts to increase the pouring-out of sweat which, on evaporating, cools the skin, and at the same time it relaxes the blood vessels and allows a larger amount of the warm blood from the interior of the body to flow through the cooled surface.

The internal environment may be disturbed by both internal and external conditions. A few examples will make clear the nature of these disturbances. In muscular work, for instance, there is a great production of non-volatile lactic acid. The immediate way in which this can be got rid of effectively is by burning it to carbonic acid. This requires the delivery of abundant oxygen to the muscles where the burning occurs, and at the same time the carriage of the resulting carbonic acid from the muscles to the lungs where it is breathed away. This more ample transportation of the respiratory gases, which protects the body against the development of a dangerous acid reaction, is brought about by the sympathetic system, for the faster heart rate, the higher blood pressure from vasoconstriction—resulting in a faster blood flow to the active muscles where vessels are dilated—and the increased concentration of red corpuscles from contraction of the spleen are all due to action of the sympathetic. But muscular work also produces a large quantity of heat. If this could not be got rid of, our activities would be promptly checked by a degree of temperature so high that it would be perilous. The sympathetic is again effective, and by an abundant output of sweat prevents the body from becoming overheated. In muscular work, also, sugar is largely employed. There is little danger of the convulsions from low sugar content, however, because from the liver the sympathetic system releases sugar as it is needed. From these observations it is easy to understand why sympathectomized animals—the dog, for example, trained to run in a treadmill—become much less efficient if the sympathetic system has been removed.

I have considered the rôle of the sympathetic in maintaining constancy of the internal environment when there is danger that the temperature may fall. It is a point of great interest that sympathectomized animals when exposed to cold are no longer able to protect themselves by the usual reactions and have to utilize to an unusual degree the only defense which remains to them, namely, the automatic muscular contraction of shivering, which, by producing heat, helps to prevent the temperature from falling too low.

Now that I have laid this rather broad basis for an understanding of the influence of the sympathetic system on the internal environment, I wish to make clear the relation of emotional excitement to that environment. Already I have emphasized the point that the central control of the sympathetic system is to be found in the diencephalon—I need only refer again to Bard's evidence that the neural mechanism of sham rage has its locus in the hypothalamus. Under normal conditions, as we have already seen, the changes which take place in great rage or fear can be interpreted as useful adaptations of the body for vigorous struggle. It should be clear, however, that if no struggle occurs and an intense emotional state persists, the changes occurring in the body no longer are a preparatory safeguard serviceable in fighting or flight, but may be on the contrary profoundly disturbing. In present-day civilization we have many occasions for fears, anxieties and worries when there is no vigorous bodily reaction called for. The financier who watches the downward course of his

security-values or the waning of the returns from his investments, the applicant for a position who is about to undergo a severe physical and mental test, the mother who realizes that she has lost control of a wayward son or daughter, the anxious and responsible patient who faces a serious operation—all these cases illustrate the situations which may develop intense emotional turmoil in the body, when energetic action for defense or escape is impossible. The bodily adjustments characteristic of the emotional state appear, in their natural manner, but are now not only quite futile, but, worse than that, quite likely to be damaging.

We have seen that the faster heart beat and the heightened blood pressure from splanchnic stimulation are useful in the swift carriage of the respiratory gases—and that this change occurs both in vigorous exertion and as an accompaniment of fear or rage, which may be attended by the need for such exertion. But the sympathetic nerve impulses, which constrict the blood vessels of the splanchnic area and thus deprive the digestive organs of much of their blood supply, simultaneously inhibit the digestive functions which can not continue when the circulation is deficient. Thus, if this unitary sympathetic system is brought into action by strong emotions, there is not only the mobilization of the bodily forces previously described, but a stoppage of the beneficent processes of digestion. Cabot cites a case of a man whose broken leg mysteriously failed to knit. The patient, an ignorant foreigner to whom the hospital was an utterly strange place, had been left uninformed concerning the welfare of his family. After some time this fact was discovered, whereupon he was completely reassured. When this occurred, the normal course of repair began and continued to a satisfactory healing. The explanation offered for the phenomenon was that the anxiety and distress occasioned by fear for his family's welfare deeply interfered with the digestive and nutritive functions and thus retarded the bony union. In the literature on diabetes there are many instances of the state becoming much intensified by emotional upsets such as rage and fright—an effect caused, no doubt, by sympathetic impulses. The best explanation of the sensitive heart—the "D. A. H." of wartime—is that it has its origin in emotional instability. These and other examples which could be cited are clear indications of the way in which the emotional level, by affecting the sympathetic system—the system in control of constancy of the internal environment—may have harmful influence on the organism as a whole.

Thus far we have considered the emotional level in lower centers of the brain stem as being under an inhibitory government from the cortex. The cortex is the agency of our voluntary acts. We have already seen that although the cortex can voluntarily check the expression of emotion in skeletal muscles, it can not directly influence the changes in viscera which are brought about by discharges from the diencephalon. This does not mean, however, that the cortex is not concerned with control of emotional situations. The visceral changes produced in such situations may, to be sure, be conditioned reflexes, described by Pavlov, in which a direct and inborn stimulus for a certain act becomes, by association, related to the circumstance prevailing at the time the stimulus was applied. Thus, the ringing of a bell at the time food is given may result in establishing an association such that subsequent ringing of the bell causes flow of saliva. In much the same way, the involuntary bodily reactions which characterize emotional excitement may become conditioned by the circumstance which attended their appearance. Thus, during the war the banging of a door or

any other sharp noise would not uncommonly bring about a sharp sense of danger and raise a haunting fear in persons who had been sensitized by experience with a near-by shellburst. In a similar way, other pathological conditions can be accounted for. It is recorded that a wife who happened to see her husband walking with a strange woman on the street became greatly perturbed, and on rushing anxiously into her house found that her heart was palpitating in a distressing manner. The palpitation appeared whenever she ventured on the street. She was convinced that she was suffering from a disease of the heart, although her physician explained that there was no evidence of cardiac derangement. The case can be readily accounted for by a conditioning of the patient to publicity on the street by the emotionally upsetting incident which occurred there. There are many ways in which the cortex and the lower emotional level may interplay. I have touched upon only some of the more striking relations between the two levels.

Men engaged in medical practise, whether physicians or surgeons, have many opportunities to see ways in which strong emotions may upset the organism. I have cited disturbances of digestion, of metabolism and of the heart. There are still other instances which I might mention to show the influence of the emotional level. In conclusion, may I urge the propriety of recognizing where the organic seat of emotional disturbances is to be found. As we have seen, it lies in the ancient part of the brain—a part of the brain which we share with lower animals. It is a region where the primitive reactions of attack and defense have their source. It is associated with the functioning of the sympathetic division of the autonomic nervous system—a system which regulates body heat, which regulates blood sugar, which governs the acid-base relation of the blood, and it may be concerned with the water balance, fat metabolism and the phenomenon of sleep. Obviously, when this region is brought into activity, as is certain to be the case in strong emotional excitement, it may, as we have learned, deeply affect the internal environment of the body and thus determine for weal or woe the fate of the whole organism.

WHAT IS A FIFTY-POUND WEIGHT?[1]

By RALPH W. SMITH

CHIEF, SECTION ON WEIGHTS AND MEASURES LAWS AND ADMINISTRATION,
THE NATIONAL BUREAU OF STANDARDS

WHAT is a fifty-pound weight? A most simple query—naturally, a fifty-pound weight is a weight which weighs fifty pounds. But that answer is about as helpful to the uninformed seeker after knowledge as was the definition once given for "categorical syllogism" as "a syllogism expressed in categorical terms." Perhaps it is desired to know just what a "weight" is, just what is meant when it is said that something "weighs" so much, and, moreover, just what a "pound" is, anyway.

To provide satisfying answers to these secondary questions, it will be well to begin at the beginning and say first that the "mass" of a given body is the quantity of matter comprising it, and that so long as no portion of this body is removed and nothing is added to it, its mass remains constant. Now in the case of two masses, these attract one another with a force which is directly proportional to the product of their masses, and inversely proportional to the square of the distance between their centers of mass. The whole earth may be considered as one mass which will attract a body or mass at or above its surface; and the force of this attraction varies, in accordance with the general law just stated, directly as the mass of the small body and inversely as the square of the distance of its center of mass from the center of the earth. Due, however, to the rotation of the earth, a body moving with the earth is also acted upon by a centrifugal force which, in general, is greatest at the earth's equator and diminishes toward the poles. The resultant of these two forces—the attraction between the body and the earth and the centrifugal force due to the earth's rotation—is known as the force of gravity.

Determinations of the intensity of the force of gravity, made at different points on the earth's surface, show that at some points there are unexplained variations from the anticipated values; it is also found that the conformation of the surrounding terrane has an observable effect. In general, however, considering elevation alone, and positions on or above the surface of the earth, the force of gravity exerted upon a body is found to be very nearly inversely proportional to the square of the body's distance from the center of the earth; considering latitude alone, the force of gravity is found, in general, to be uniform for a given latitude, and to increase slightly and with approximate uniformity as the poles are approached.

From the foregoing it follows that if we can measure this force of gravity upon a given body, and if we can eliminate or correct for the effects of comparative elevation and of the other factors noted, we have at once a basis for comparing the mass of the body in question with the mass of any other body upon which we can similarly measure the force exerted by gravity. If we now express this measured force in terms of some acceptable unit, we are enabled clearly to define the mass of the body or

[1] Publication approved by the director of the Bureau of Standards of the U. S. Department of Commerce.

the amount of material of which it is composed.

The expression "weight" is used to mean a measure of the force of gravity exerted upon any body. This force or weight is measured by counterbalancing it with a similar force acting upon a body or bodies of known mass or with some counter-force of known value; when equilibrium is established, the two forces are equal, and the value of the previously unknown mass is thus directly or indirectly ascertained. The bodies of known mass are called "weights." The "counter-force of known value" may be supplied by a spring, a hydrostatic assembly, a "pendulum" scale assembly or otherwise, usually acting through a system of levers; in this case, the known value of the counter-force has been determined by resorting to weights. In other words, what we commonly call a "standard weight" is really a standard mass of metal or other material by comparison with which the masses of other bodies may be determined through measurement of their respective weights.

In commercial transactions involving quantity determinations, the important consideration is to determine the mass or the amount of commodity; since these determinations are made, however, in terms of weight, as just defined, the expression "weight" is loosely used to represent the amount of commodity. Thus "100 pounds of steel" really means a mass of steel such that the force of gravity exerted upon it is 100 times greater than the force of gravity which is or would be exerted, under the same condition, upon a standard mass known as the "pound." However, since the units of mass and weight are identically named, and since no practical purpose would be served in commercial transactions if the two were to be distinguished, the distinction between them may be considered of scientific interest and importance only, and the commercial usage in which the expression "weight" is used in the sense of "mass" need not be condemned.

In reference to the gravitational force acting on a body, it has been said that this is a function of the distance of the center of mass of the body from the center of the earth. The magnitude of the effect of a change of elevation upon the gravitational force exerted upon a given body is of the order of one part in 2,000 for a change of elevation of 6,000 feet, the "weight" being less the greater the elevation. But if we have weights which are standard according to some accepted basis, and use these on an "equal-arm" balance to determine the "weight" of an unknown amount of commodity, the accuracy of the result, upon the accepted basis, will be independent of the elevation at which the determination is made and check determinations made at different elevations should agree, because the change in the intensity of the gravitational force affects equally the standard weights and the commodity being weighed. The same would be true in the case of a weighing mechanism employing a compound-lever system. In any case, however, where a spring is utilized as the ultimate counter-force, disregarding other effects, different results would be obtained at different elevations, provided that the weighing mechanism were susceptible of indicating the differences actually existing. In the case of such a device, if the assembly is sufficiently sensitive to respond to weight differences resulting from a change of elevation, and if such differences of indication may be read upon the device in question, it should be calibrated against standard weights at the elevation at which it is to be used, thus making its indications standard for that

elevation. In the case of ordinary commercial devices, however, it is probable that these differences can never be observed, and in any event they are of such small magnitude, relative to the graduations on the commercial device, that they may be entirely disregarded.

Let us now proceed to a consideration of "What is a pound?" If we refer to the dictionary we find "pound" defined as "a unit of weight varying in value from about 300 to about 1,070 grams and commonly divided into 12 or 16 ounces." From this definition it would appear that the pound is not a very definite unit of weight. The dictionary further tells us, however, that the avoirdupois pound of 7,000 grains is used in this country in the weighing of most commodities, but that the troy pound of 5,760 grains is used in certain restricted fields of weighing. If we pursue our researches farther afield and endeavor to trace the history and determine the origin of the units which we know as pounds, we can go back, step by step, until we finally reach a point where recorded history ceases and beyond which we can not proceed for lack of authentic data.

As to the pounds of the United States we know, of course, that these came to us from England. As to the history of the English standards, the following is quoted from "Men and Measures," by Edward Nicholson, an English author:

> Our pound [the Imperial pound of Great Britain] settled at its present Imperial standard in the time of Queen Elizabeth, was then found to have risen slightly since the time of Edward III. It was found to have increased by about 8 grains. The ounce, now = 437½ grains, had been 437 grains, the same weight as the ounce of the Egypto-Roman pound, the Roman libra. There is every reason to believe that this Roman standard passed to Britain, and that the libra, raised to 16 ounces, became the commercial pound, afterwards known as Averdepois, and now the Imperial pound.
>
> When the Romans took the Alexandrian talent as the standard of their new libra-system, they divided it into 125 librae, which were 1500 ounces or double-shekels, each ounce = 437 grains.
>
> . . . It is not improbable that the survival of the Roman commercial pound in Saxon England was strengthened by commercial and scientific relations with the Moors of Spain.
>
> . . . However this may have been, there seems no doubt that the Roman pound, raised to 16 ounces, was the standard of England before as after the Norman conquest, and there is no evidence of it having ever been in abeyance. . . .

The same author gives a table of Roman weights reading in part as follows:

> Libra = 5244 grains
> Uncia = 437 grains
> Drachma = ⅛ uncia = 54.6 grains
> Scrupulus = ⅓ drachma = 18.2 grains

Here will be recognized certain terms and relations familiar to us in our present apothecaries' table. According to Mr. Nicholson, the Roman ounce of 437 grains was in England taken 16 times to make the commercial pound of 6,992 grains, and to this pound 8 grains were subsequently added to give an even figure of 7,000 grains for the pound.

Considering the origin of the Roman pound we find that this, in common with other ancient standards of weight, was derived from a standard of linear measure. The principal ancient linear unit was the cubit. There were a number of these, the most important being the

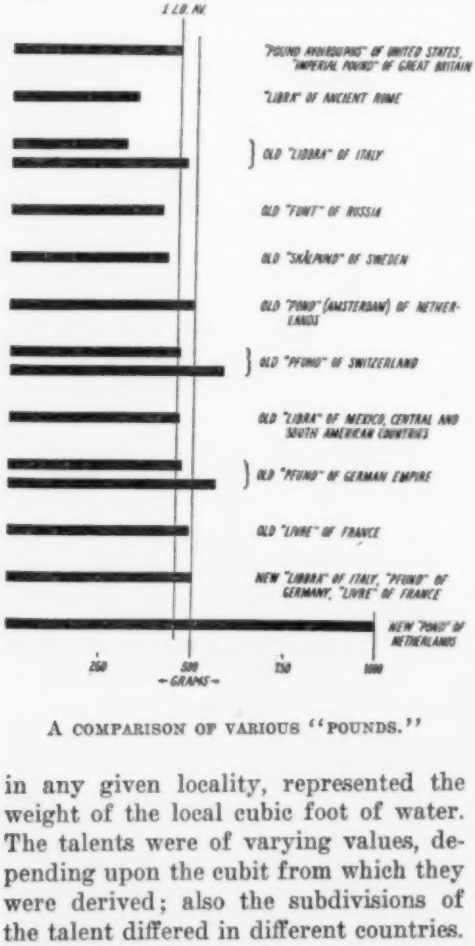
> Egyptian common cubit of 18.24 inches, its foot being two-thirds of this or 12.16 inches.
> Egyptian Royal cubit of 20.64 inches, its foot being two-thirds of this or 13.76 inches.
> Great Assyrian cubit of 25.26 inches, its foot being one-half of this or 12.63 inches.
> Beladi cubit of 21.888 inches, its foot being one-half of this or 10.944 inches.
> Black cubit of 21.28 inches, its foot being two-thirds of this or 14.186 inches.

Speaking of these cubits, Mr. Nicholson says:

The history of the five cubits, ancient and medieval, has shown that they were all derived, directly or indirectly, from the Meridian measurement of the earth, some of them being probably instituted with the desire to make them representative of the relation of latitude and longitude.

I venture to say that every measure and weight used throughout the world has been developed from one of these cubits. . . .

The principal ancient unit of weight appears to have been the talent which,


1 LB. AV.
"POUND AVOIRDUPOIS" OF UNITED STATES, "IMPERIAL POUND" OF GREAT BRITAIN
"LIBRA" OF ANCIENT ROME
OLD "LIBBRA" OF ITALY
OLD "FUNT" OF RUSSIA
OLD "SKÅLPUND" OF SWEDEN
OLD "PUND" (AMSTERDAM) OF NETHERLANDS
OLD "PFUND" OF SWITZERLAND
OLD "LIBRA" OF MEXICO, CENTRAL AND SOUTH AMERICAN COUNTRIES
OLD "PFUND" OF GERMAN EMPIRE
OLD "LIVRE" OF FRANCE
NEW "LIBBRA" OF ITALY, "PFUND" OF GERMANY, "LIVRE" OF FRANCE
NEW "PUND" OF NETHERLANDS
250
500
750
1000
GRAMS

A COMPARISON OF VARIOUS "POUNDS."

in any given locality, represented the weight of the local cubic foot of water. The talents were of varying values, depending upon the cubit from which they were derived; also the subdivisions of the talent differed in different countries. Many of the terms which we associate with ancient monetary units were in reality primarily subdivisions of the talent as a weight unit.

This line of investigation might be pursued almost indefinitely, tracing the relationships between the various weight units of ancient times and their connections with units of the present day, but enough has probably been said to demonstrate that there is a direct connection between our present-day standards and those of very ancient times, both as to values and names. This mention of similarity of names for corresponding weight units suggests a brief excursion into the field of modern nomenclature. Mention has already been made of the Roman libra, a word which seems to be responsible for our present abbreviation of "lb." for pound. The Roman uncia, the Greek drachma and the Roman scrupulus have already been mentioned as the derivations of the modern ounce, dram and scruple. We find that in modern times the funt of Russia, the libbra of Italy, the libra of Spain, Portugal and various South and Central American countries, the livre of France and Greece, the pfund of Germany, the pond of Java and the Netherlands, and the pund of Denmark and Sweden, correspond to the avoirdupois pound, as we know it, although the exact equivalents in terms of our pound vary from about $\frac{3}{4}$ to over 2 pounds.

The development of the word "avoirdupois" is also interesting. We find this word variously spelled in old English documents as "Haberty poie," "Haberdepase," "Avoirdepois," etc. "Aver" is said to be an old established English word meaning "goods," and the combination in question is said to mean "goods of weight" or "heavy goods." Some of the old statutes refer to this pound as the one to be used for the weighing of corn, heavy goods, meat and fish, a distinction apparently being drawn between such commodities and more expensive commodities, such as spices, precious metals, precious stones,

etc., which were weighed in small amounts. By the avoirdupois pound, then, is meant the pound for heavy goods as distinguished from the troy pound used by the gold and silver smiths and in connection with the coinage. "Avoir" in modern French also has the meaning of wares or merchandise, so we can arrive at the same meaning for "avoirdupois" by considering the word as of French origin.

And now let us consider some facts about our own United States pound. For a complete discussion of our standards, the reader is referred to the paper of Louis A. Fischer on "The History of the Standard Weights and Measures of the United States," published as Bureau of Standards Miscellaneous Publication No. 64. For our present purposes we need only sketch briefly the points which Mr. Fischer discussed in detail.

Colonial weights were of English origin and corresponded to those in use in England prior to the formation of the Colonies. There was considerable divergency, however, among the weights of the several colonies, and this persisted after the formation of the Union. Repeated efforts were made to have Congress correct this condition, but without success. Finally, in 1828, Congress decreed that a certain troy pound which had been procured in England, and which was supposed to be an exact copy of the imperial troy pound of Great Britain, should thereafter be the standard for the coinage of the United States. Two years later Congress ordered that a comparison be made by the Treasury Department of the weights at the principal custom-houses. Large individual discrepancies were found, but the average values for the different denominations were found in fairly good agreement with the weights used in England at the time of the Revolution. In order to construct uniform weights to be furnished the custom-houses, the Treasury Department found it necessary to adopt a definite standard; it was decided that the relation between the avoirdupois pound and the troy pound of the Mint should be as 7,000 is to 5,760, this being the relation previously accepted in the United States and in England.

Uniform standards having been furnished to the custom-houses, Congress in 1836 directed that copies of these be furnished the several states, and as additional states were admitted to the Union they were also supplied with standards; North Dakota, in 1893, was the last state to receive one of these sets.

In the year 1870 there was held in Paris a conference to which various nations had been invited by the French Government to send their representatives, to consider the advisability of constructing new standards of the metric system. This and subsequent conferences were attended by representatives of the United States, and these meetings resulted in the decision to construct new metric standards, and in the signing of a treaty providing for the formation and maintenance of an International Bureau of Weights and Measures. This international institution is supported by the various countries signatory to the treaty and is controlled by an elected committee upon which the United States has always been represented.

New metric standards having been constructed by a special committee appointed for that purpose, these were compared with the old metric standards by the international bureau, and at a general conference held in 1889 the new kilogram, which agreed most closely with the kilogram of the Archives, was declared to be the international kilogram; the other kilograms were distrib-

uted by lot to the various governments supporting the international bureau, the United States receiving kilograms Nos. 4 and 20. These were brought to this country in 1890, kilogram No. 20 arriving in January and kilogram No. 4 arriving in July. Kilogram No. 20 was accepted by President Harrison upon its arrival as the national standard, and both standards were deposited in the Office of Weights and Measures of the Coast and Geodetic Survey. On April 5, 1893, the Superintendent of Weights and Measures, with the approval of the Secretary of the Treasury, decided that the international kilogram would in the future be regarded as the fundamental standard of mass in the United States, both for metric and customary weights.

The Office of Weights and Measures used as the relation between the avoirdupois pound and the kilogram the equivalent, 1 pound avoirdupois equals 0.4535924277 kilogram, a value determined by the joint work of the International Bureau of Weights and Measures and the British Standards Office. When the National Bureau of Standards was established in July, 1901, the decision of the Office of Weights and Measures to recognize the international kilogram as our fundamental standard of mass, and the equivalent just given as the relation between the avoirdupois pound and the kilogram, were fully accepted by the Bureau and are so accepted to-day.

Earlier in this paper it was indicated that when we speak of a "standard" weight we mean a weight which is standard according to some accepted basis. The following statement represents the practise accepted in the United States as that upon which weights of Classes A, B and C are to be considered standard:

The calibration is based upon the apparent mass as determined at 20° C. in air having a density of 1.2 milligrams per milliliter, against standards having a density of 8.4 grams per cubic centimeter at 0° C., whose coefficient of cubical expansion is 0.000054 per degree Centigrade, and whose values are based on their true mass or weight in vacuo. The scope of this paper is not broad enough to permit of a discussion of each of the factors just mentioned. Those desiring to go somewhat into detail on these matters will find them discussed in Circular No. 3 of the Bureau of Standards, Design and Test of Standards of Mass.

To sum up, then, the situation in relation to the United States avoirdupois pound is this: The pound is defined in terms of the kilogram, the relation being 1 pound avoirdupois equals 0.4535924277 kilogram. The international kilogram, preserved at the International Bureau of Weights and Measures, Sevres, France, is our fundamental standard of mass; our national primary standard is the kilogram preserved at the Bureau of Standards, the value of this in terms of the international standard being known with the highest accuracy attainable by the modern metrologist.

The United States primary kilogram is used upon rare occasions to verify the accuracy of the reference standards of the mass laboratory of the Bureau of Standards, which, in turn, are utilized to check the accuracy of the laboratory's working standards. These latter standards are of various denominations, suitable for the comparison of weights submitted to the Bureau for test.

When examinations are made at the Bureau of the primary standards of weight of a state, the errors of those standards are determined and reported to the state in a certificate returned with the weights, so that the state may have in its possession authentic standards of known values with which to control its

own testing activities. The state primary standards are then used by the state to prove its secondary or office working standards, the latter are used in testing the field or inspectors' working standards, and the field standards are carried to the commercial establishments using weights or weighing equipment, there to be used in the final step of the long series of comparisons beginning with the International Kilogram and ending at the merchant's counter.

So now if a fairly concise answer were to be made to the original question of "What is a fifty-pound weight?" this might take the following form: A fifty-pound weight is an object, usually of metal, having such a mass that, when compared in air under specified conditions, the gravitational force acting upon it is just fifty times as great—within appropriate tolerances, of course—as the gravitational force acting upon a standard mass of specified characteristics known as the "pound," which is equal to 0.4535924277 kilogram.

SCIENTIFIC METHODS OF OYSTER FARMING[1]

By Dr. HERBERT F. PRYTHERCH
DIRECTOR, U. S. FISHERIES BIOLOGICAL STATION, BEAUFORT, N. C.

IT is sometimes said that the oyster is found in nearly all bodies of water except the oyster stew. If such a doubtful condition did exist the oyster can at least plead "not guilty" and offer as evidence in his defense the 152 million pounds of oyster meats which he furnishes annually to the people of the United States. This would allow for each person approximately one and a quarter pounds of the most healthful food product harvested from the sea. Both the edible and non-edible portions of the oyster are of economic importance, the former yielding a return to the fishermen of $17,074,000 in 1929, while the latter or oyster shells converted into poultry feed and lime were valued at $2,524,499.

The first question of human existence is, "When do we eat?" to which the early inhabitants of our shores, the aborigines and Indians, must have frequently replied with appropriate grunts and gestures, "at low tide." Oysters and other shellfish could then be easily gathered from the natural beds on the tidal flats or in shallow water, and judging from the huge oyster shell mounds of ancient origin this bivalve was an important item on the bill of fare at their primitive feasts. In Maine, at the mouth of the Damariscotta River, one mound, containing over 8 million cubic feet of shells, was found as a great monument to the antiquity of oysters on this coast. In the near-by streams, the Sheepscot and George Rivers, the Indians apparently transplanted oysters from the Damariscotta to keep them alive near home, thus indicating the earliest evidence of oyster culture in America.

Oysters were a valuable food resource in the early struggles of the Pilgrim Colonists against starvation and deemed of sufficient importance at Plymouth for the passing of restrictive laws before the end of the seventeenth century for protection of the oyster beds. As time went on the natural beds were rapidly depleted, particularly those in the northern coastal areas, and led to earlier and greater developments in this section for producing oysters by cultivation.

Oyster farming has become an important industry on both the east and west coasts of the United States. By the use of modern scientific methods and equipment, the oyster farmer has greatly increased the production of this shell-fish, improved their quality and converted thousands of acres of useless bottom into valuable food-producing areas.

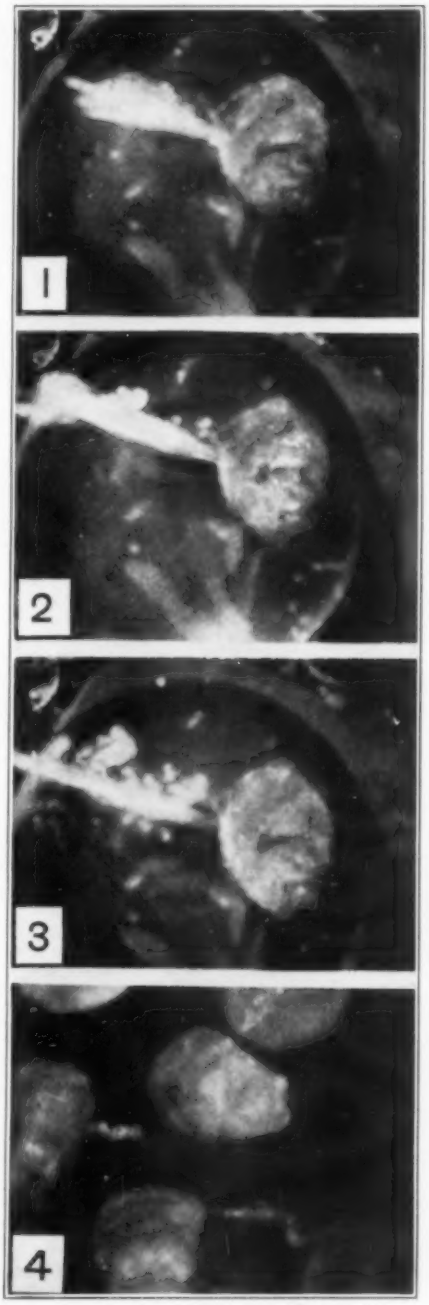
The commendable progress that has been made in this phase of aquiculture can be attributed largely to the gradual accumulation of more accurate knowledge concerning the oyster and its environment. Reliable information and facts of fundamental and practical value to the industry have been contributed by both oystermen and scientists. Oystermen have learned through their own experiences the value of experimental methods. In their own way they have conducted innumerable experiments, many of them costly, in order to find new oyster growing and maturing grounds or better methods for increasing production and improving the quality of their product. The early experiments in shell planting, transplantation of seed, deep-water culture, etc., served as

[1] Published by permission of the U. S. Commissioner of Fisheries.

a foundation and stimulus to the extensive, present-day developments in oyster farming. As these oyster cultural activities increased in magnitude it was found that similar results were not obtained from year to year, or in different localities, and that these expensive operations were more or less of a gamble each season. Nearly every oysterman had certain "pet" theories as to the principal factors controlling oyster growth and propagation, but these frequently failed as intelligent guides in oyster farming and involved considerable losses in labor and materials.

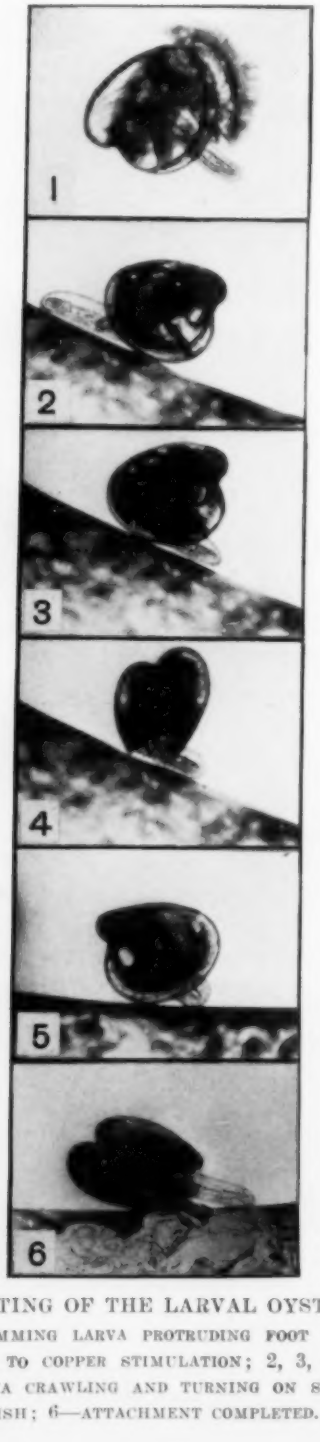
The leading men of the industry soon realized that the real facts concerning the oyster must be determined by scientific study in order that commercial operations might be conducted on a sound basis. In response to their requests numerous scientific investigations have been made of the oyster by research workers from the state and Federal departments of fisheries and public health and by individuals from universities and private institutions. Many difficult and important problems pertaining to the oyster and its environment have received the careful attention of the biologist, bacteriologist, chemist and nutrition expert. In our scientific studies we have made considerable progress and have discovered many essential facts concerning this shell-fish that are of practical value to the industry. Though such advances as have been made to date are but a beginning they have clearly demonstrated that research is one of the best forms of security for capital invested in the oyster industry.

Three species of oysters are being cultivated in the United States. The most important of these, *Ostrea virginica* or the so called "eastern oyster," occurs naturally on the Atlantic and Gulf coasts and comprises over 99 per cent. of the annual yield. On the Pacific coast intensive cultivation of the native



OYSTERS SPAWNING

1, 2, AND 3—VIGOROUS DISCHARGE OF EGGS BY THE FEMALE; 4—GRADUAL RELEASE OF SPERM BY MALE OYSTERS.



SETTING OF THE LARVAL OYSTER

1—SWIMMING LARVA PROTRUDING FOOT IN RESPONSE TO COPPER STIMULATION; 2, 3, 4 AND 5—LARVA CRAWLING AND TURNING ON SIDE OF DISH; 6—ATTACHMENT COMPLETED.

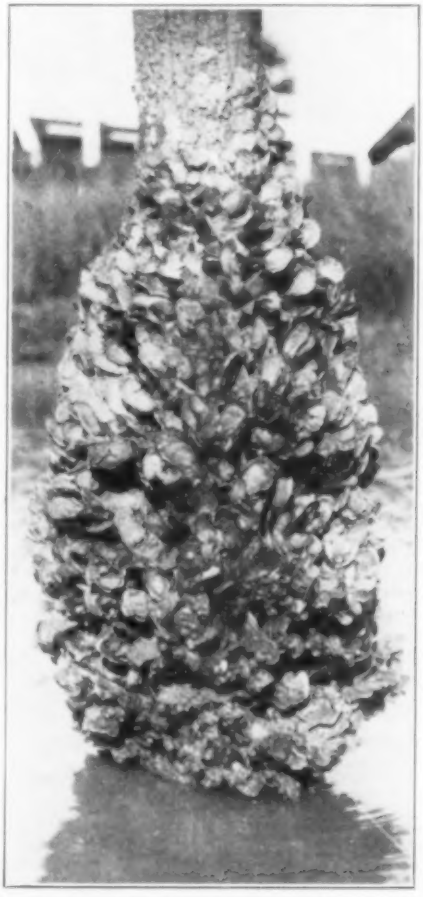
oyster, *Ostrea lurida*, and an imported Japanese species, *Ostrea gigas*, is carried on chiefly in the State of Washington. The oyster lends itself readily to cultivation, first, because it is unable to move of its own volition from the beds on which it is placed; second, because it can withstand rough handling and long exposure to air; and third, because of its interesting and unusual life history, which makes possible unique methods for controlling and increasing its production. In the last 10 years the efficiency of cultural operations has been greatly advanced on the basis of information obtained from scientific studies of the more important stages in the development of the oyster, the physiological processes of the adult, the influence of environment conditions, etc.

Starting with the reproductive activities, research has shown that a single female oyster may produce under favorable conditions as many as 100,000,000 to 500,000,000 eggs during one season. Naturally the eggs are microscopic in size (1/500 of an inch in diameter) and occupy so little space that it would be possible to place in a one-quart bottle enough to supply our annual oyster crop of over 20,000,000 bushels. The fecundity of the oyster enables us to make further interesting calculations, *i.e.*, if all the eggs produced in our coastal waters during one favorable season were to survive and grow to market size there would be enough to cover the entire country with a layer of oysters over 30 feet deep. Egg production has been found to vary greatly, however, from year to year and sometimes when amounting to only a few million per oyster is insufficient to produce an adequate supply of spat or seed oysters. An annual fluctuation of only 10 million per oyster becomes significant, as it indicates that for each acre of adult oysters there will be a total increase or decrease of approximately 100 billion to 300 billion in egg production. In Long

Island Sound, the greatest oyster-farming region in the world, it has been possible to establish a direct correlation between water temperature (from April to July) and the success or failure of spawning and propagation of seed. When water temperatures are above normal during this period, egg production is greater and results in a proportionate increase in the supply of seed. For several years advance information and predictions along this line have been furnished by the Bureau of Fisheries as a guide to the oystermen in their expensive operations of planting shells and other materials for collection of seed. By taking advantage of the favorable years and planting a greater quantity of shells it has been possible to increase the supply of seed and adult oysters in these waters.

Studies of the spawning of the oyster show that water temperature and mutual stimulation of the sexes are the important controlling factors. No spawning occurs below 20° C. Ripe males shed sperm at 20° to 24° C., while the spontaneous discharge of eggs by the female requires a temperature of 24.5° C. or above. On the other hand, the spawning reaction may be induced at slightly lower temperatures by the addition of reproductive products of the opposite sex. Under natural conditions the males spawn first, and the process, once started, spreads by mutual stimulation of the two sexes throughout the whole oyster bed. To insure successful propagation of the species the oyster farmer establishes spawning beds where water temperatures are favorable and concentrates the plantings of adults so as to facilitate simultaneous spawning of the oyster population and increase the possibilities for fertilization of the eggs.

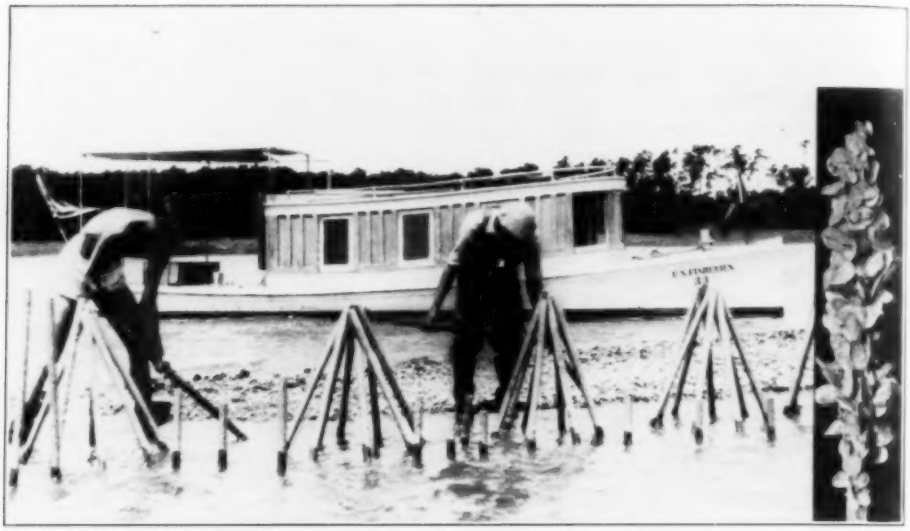
The time of spawning varies from year to year and in certain coastal areas has been found to occur during certain phases of the moon. Studies in Connecticut, North Carolina, South Carolina and Georgia show that these activities usually take place from 6 to 9 days after either full moon or new moon. Indirectly the moon is responsible for spawning at such times because of its influence



DISTRIBUTION OF OYSTERS ON A PILE IN FOLLY RIVER, S. C.

SETTING OCCURS HERE ONLY ABOVE LOW WATER MARK AND CAN BE DIRECTLY CORRELATED WITH VARIATIONS IN COPPER CONTENT OF THE WATER.

on the tides and water temperature. The higher tides at times of full or new moon cause the water to pass over a greater area of tidal flats, where it absorbs, particularly during the early summer months, considerable heat from



PLANTING SEED OYSTER COLLECTORS NEAR BEAUFORT, N. C.

CEMENT-COATED, PAPER TUBES ARE SET OUT ON MUD BOTTOM NEAR OYSTER REEF TO PROVIDE PLACE OF ATTACHMENT FOR LARVAL OYSTERS. INSERT—SINGLE TUBE, 9 MONTHS LATER, COVERED WITH SEED.

the land and sun's rays. During these periods increases of 8° to 10° C. in water temperature have been observed and can be correlated with spawning. By means of observations on range of tide, water temperatures and ripeness of oysters, it has been possible in Long Island Sound to determine approximately one month in advance when spawning will occur. In oyster farming this information has proved of considerable value and is now used by the industry for correctly timing the planting of seed-collecting materials. This is the most important operation in oyster culture and must be completed not later than two weeks after spawning, when attachment of the larval oysters occurs.

The development of the oyster from the egg to the stage when it sets or cements itself to some clean submerged object usually requires from 13 to 16 days. In 2 to 3 hours after spawning the fertilized egg develops into a swimming larva; in 20 hours it is completely covered with a shell and swims about gathering food by means of a ciliated disk-like organ or velum; in two weeks it has completed larval development and measures approximately one seventy-fifth of an inch in diameter. Just previous to this time the larva has formed a powerful foot for crawling and a large supply of sticky material by which it anchors and cements itself to an old shell or stone. In fact, the larva is not particular as to its choice of a future home and may attach to a discarded bottle, boat, tin can, auto tire or any convenient clean surface. In different oyster regions various terms such as setting, striking, spatting, catching and fixation are used to designate the attachment process, which is the most important and critical phase of the oyster's development. Both the survival of the oyster and the success of cultural operations depend largely on the ability of the larva to find and firmly immobilize itself on a suitable object.

Setting is usually completed in from 20 minutes to one hour, according to the

salinity of the water and requires a definite chemical stimulus for its initiation. Copper is the only known element that will induce this reaction and has a pronounced effect under natural conditions in minute concentrations of one part copper in 2 to 10 millions of sea water. Surface and underground waters leach copper from the soil and transport it to the inshore coastal areas. On passing into sea water the dissolved copper forms a colloidal precipitate (copper oxychloride) and in this form is taken into the digestive tract of the larval oyster. In about 4 minutes the larva begins the setting process and after crawling back and forth over the surface of some convenient object finally secretes a quick-hardening cement with which its shell is firmly attached to the substratum. The oyster is now definitely fixed for the rest of its life or at least until some ruthless oyster tonger or cultivator knocks it off for market or for transplantation to other beds.

Cooperative experiments of the biologist and oyster culturist have shown that setting is heavier and occurs with greater regularity in certain inshore coastal areas. In many of these locations natural oyster beds existed in the past but have since been depleted by over-fishing and pollution. The oyster farmer has reclaimed and rehabilitated most of this territory by the establishment of spawning beds and now utilizes these bottoms for the collection of seed oysters. Large quantities of shell are planted there at the proper time and gather in many instances many million more spat than can survive on the available surface. For example, a single shell oftentimes collects from a few hundred to several thousand spat, while there is only room enough for 25 or 30 to survive. With such intensive setting, a very high percentage (98 to 99 per cent.) of the spat die from overcrowding, lack of food, oxygen, etc.; and those surviving are so closely cemented to-

INTENSIVE SHELL PLANTING OPERATIONS ON SEED BEDS IN NEW HAVEN HARBOR, CONN.

BY PLACING SHELLS IN BAGS THE PRODUCTION OF SEED OYSTERS PER UNIT OF BOTTOM CAN BE INCREASED MANY TIMES.

gether and misshapen as to be of little value as seed oysters.

The loss of a large potential supply of seed under such conditions has been overcome to a great extent by (1) increasing the planting of shell during favorable years as described previously and (2) by the use of special spat-collecting devices. Several practical types of artificial collectors have been developed by the Bureau of Fisheries by which the yield of seed oysters on a given area of bottom can be increased from 10 to 50 times, as compared with the usual practise of scattering shells. For this purpose wire bags filled with shells, cement-coated partitions, tubes and expanded mats of waterproof paper have proved satisfactory. By planting these devices singly or in stacks it is possible to present a greater area of surface for the attachment of the oyster larvae and utilize the three dimensions of seed-producing bottoms. In one experiment in Milford Harbor, Connecticut, a planting of 7,000 partitions collected over 20,000,000 spat, while an equally heavy set was also obtained on the layer of shells over which they were placed. With stacks of shell bags it has been possible to collect spat on 8 or 10 bushels of shell per square yard, thus saving millions of seed that otherwise would be lost. The intensity of setting in bags planted in New York, Connecticut and Massachusetts ranged from 1,500 to over 65,000 spat per bushel of shell and was found to vary according to seasonal conditions, position of spawning bed and the particular tidal level at which the collectors were planted.

In Southern waters, poles, brush and cement-coated tubes have proved to be satisfactory devices for gathering seed.

A REPRESENTATIVE CROP OF OVER 300,000 SEED OYSTERS
COLLECTED IN PARTITIONS IN MILFORD HARBOR, CONN. THE SEED ARE TWO MONTHS OLD AND READY FOR DETACHMENT AND SEPARATION BEFORE PLANTING ON DEEP WATER BEDS.

PLANTING PARTITIONS FOR COLLECTION OF SEED OYSTERS, CORE CREEK, N. C.
SETTING OF OYSTER LARVAE MOST INTENSIVE IN ONE FOOT ZONE ABOVE LOW WATER MARK.
INSERT—SINGLE PARTITION TWO MONTHS LATER COVERED WITH 3,000 SEED OYSTERS.

Numerous demonstrations and experiments of the Bureau of Fisheries have shown how collectors of this type are particularly suitable for use on soft mud bottoms and offer a practical means for utilizing thousands of acres of such areas for seed production. The brush and cement-coated collectors are superior in some respects to shell in that they remain clean longer and permit detachment and separation of the seed when a few months old. The latter procedure has been found to increase the growth and volume of the oysters nearly 100 per cent. during the first year and also produces a desirable type of shell that will withstand the rough treatment of dredging and transplanting operations. By the use of improved spat collectors and more accurate planting of shells as to time, place and quantity, the oyster farmers have efficiently utilized the prolific setting areas and have overcome the serious scarcity of seed that confronted the industry a few years ago.

In the fall or spring the seed oysters are taken up and transplanted to selected growing grounds. These areas are generally located in deeper water where setting does not occur, and consequently oysters placed there are not covered and overcrowded by successive generations. On these grounds the seed oysters are given ample room for growth and reach marketable size in from two to five years, according to the locality in which they are grown. In some cases the oysters are transplanted a third time to areas where food and water conditions are excellent for fattening and will increase the volume and market value of the meats.

On the Pacific coast in the vicinity of Olympia the oyster-growing bottoms have been improved and enlarged by the construction of an elaborate system of concrete or wooden dikes. The tidal slopes are divided into a series of one acre ponds, arranged at several different levels and retaining enough water at low tide to cover the oysters. Though the construction of dikes and improvement

TRANSPLANTING A BOATLOAD OF YEAR-OLD OYSTERS
FROM THE INSHORE SEED BEDS TO SELECTED GROWING AREAS IN LONG ISLAND SOUND.

of enclosed bottoms involves an investment of $1,000 to $3,000 per acre, this type of oyster farming is highly successful and yields from approximately 10 to 45 times greater returns than any other crop (corn, oats, potatoes, cranberries, etc.) cultivated in the State of Washington.

CRUSHING PLANT IN OPERATION AT BEAUFORT, S. C.,
FOR CONVERTING OYSTER SHELLS INTO POULTRY FEED AND LIME. OVER 347,000 TONS OF THESE PRODUCTS, VALUED AT $2,595,252 WERE PRODUCED IN 1930.

Studies of the feeding of the oyster have had an important bearing on these operations in respect to the relative density of plantings for growing and maturing purposes. The oyster is a heavy drinker, especially during the warmer months, when he pumps through his gills over 15 gallons of water per day from which is extracted practically all the oxygen and suspended food materials. Some idea of the magnitude of this process can be gathered from the fact that the oysters in our coastal waters consume in the aggregate approximately 10 times as much water daily as is used by the entire population of the United States in the same period of time for domestic purposes. The oyster farmer applies this knowledge by limiting the number of oysters planted per acre according to their size and age and the relative quantity of water circulated over the beds by the tides and currents. Records of his past experiments in the cultivation of different areas are also used as an index of their potential value for growing or fattening oysters and are of considerable aid in determining the correct density of planting for each particular bed.

OYSTER GROWERS AND BIOLOGISTS INSPECTING A DREDGE LOAD OF SHELLS FOR EVIDENCE OF SEED OYSTERS (SPAT). INCREASED SHELLING OPERATIONS, BASED ON PREDICTIONS OF THE BIOLOGIST, PROVE SUCCESSFUL.

In the fall and winter as the water temperature becomes lower the feeding activities decrease and stop entirely below 6.7° C. (44° F.), when the oyster goes into a state of inactivity or hibernation. In the north the hibernation period usually extends from November until April and is an important factor in insuring the purity of the oyster and improving its condition for marketing and transportation. The oyster farmer, in harvesting his crop in the cooler

weather from his selected maturing Health the sanitary quality of the oysbeds, brings the oysters to market when they are in the best possible condition. Bureaus of Chemistry and Public ters and the waters in which they are Through the work of Federal and State grown is carefully supervised and guaranteed by standards equal to those used for milk and drinking water. Some concerns go still further and treat their oysters before shipment in chemically purified sea water, which greatly improves their sanitary and keeping qualities through destruction of bacteria and spoilage organisms.

The final step in the preparation of oysters for market is the shucking or removal of the meat from the shell. This laborious and expensive process, exceeding in cost all other oyster-farming operations and involving an annual expenditure of over $1,500,000, has also received scientific investigation.

The chief difficulty in shucking an oyster, that of gaining admission to the shell, has been overcome by putting the oyster to sleep in a harmless narcotizing solution of acidified fresh or salt water. A small amount of acid, such as acetic, hydrochloric, etc., reacts with the shell carbonates producing an excess of carbon dioxide which in turn induces relaxation of the oyster muscle with automatic opening of the shell.

Continuation of these studies at the U. S. Fisheries Biological station at Beaufort, N. C., show that the time required for opening can be reduced from several hours to a fraction of an hour by jarring or hitting the oysters before treatment. By a combination of physical and chemical agencies it is now possible to open bivalve shell-fish with less expense and labor and also improve their sanitary condition.

With the present trend of national events it may prove advisable to employ ethyl alcohol for narcotizing and opening oysters, as our investigations show it to be particularly suitable for this purpose. Whereas the American Indian solved this problem with the use of fire, the modern oyster farmer may go him one better and employ "firewater" to facilitate removal of the live meat of this delicious shell-fish.

HOW RIVERS CUT GATEWAYS THROUGH MOUNTAINS

By Dr. DOUGLAS JOHNSON

PROFESSOR OF PHYSIOGRAPHY, COLUMBIA UNIVERSITY

If one crosses the Appalachian Mountains, as, for example, when traveling from the Ohio Valley eastward to New York or Washington, he will find his path obstructed by a great series of parallel, heavily forested ranges. They seem almost endless, and the Indians actually called them the "Endless Mountains," the Alleghenies. If travel is by automobile, one may occasionally climb obliquely up one of the steep mountain slopes to the crest, there to get a magnificent panorama of the Endless Mountains, range following range like the waves of an angry sea. But more frequently, and particularly if travel is by train, one will turn north or south along one of the parallel valleys between the ranges, until he comes to a gap or gateway cut right through the mountain barrier. These gaps provide some of the most beautiful scenery of the Appalachian Mountains: The Hudson Gorge in the Highlands of New York, sometimes called the Rhine Valley of America; the Delaware Water Gap at the boundary between New Jersey and Pennsylvania; the water-gaps of the Susquehanna north of Harrisburg; and the water-gap of the Potomac at Harper's Ferry (Plate I), where Union troops were stationed throughout most of our Civil War to guard that strategic gateway into the fertile lands of the Shenandoah Valley.

As the traveler passes through one of these remarkable gaps, in going from one side of a mountain range to the other, he may notice two very significant things: First, that there is a river flowing through the gateway, often a great river like the Hudson, the Delaware, the Susquehanna, the Potomac or the James. Second, he may notice that the walls of the gateway are composed of extremely hard rocks, often in layers which are tilted up at a steep angle. After having crossed through several of these natural gateways, and repeatedly observed the same general relations, the inquisitive traveler may be tempted to do a little geological detective work on his own account. He may conclude that the mountain range is there simply because a layer of unusually hard rock was not worn down as low as weaker layers on either side. And he may also conclude that the river is there because in some way the river itself carved the gateway through the hard-rock mountain ridge. If he does reach such conclusions, he will have made a good beginning toward unraveling the greatest geological mystery of the Appalachian Mountains.

But it will be only a beginning. For notice this remarkable fact: The great rivers of the Appalachian region, instead of following the weak-rock layers between the resistant ridges, flow directly across one hard-rock barrier after another. Instead of taking easy courses from northeast to southwest, they take the hardest possible courses, from northwest to southeast directly across the most formidable mountain ranges in the eastern United States. This is the great mystery of the Appalachians. Why do the larger rivers flow across the rock structures, instead of parallel to them on the more easily eroded layers?

From the earliest days of geological

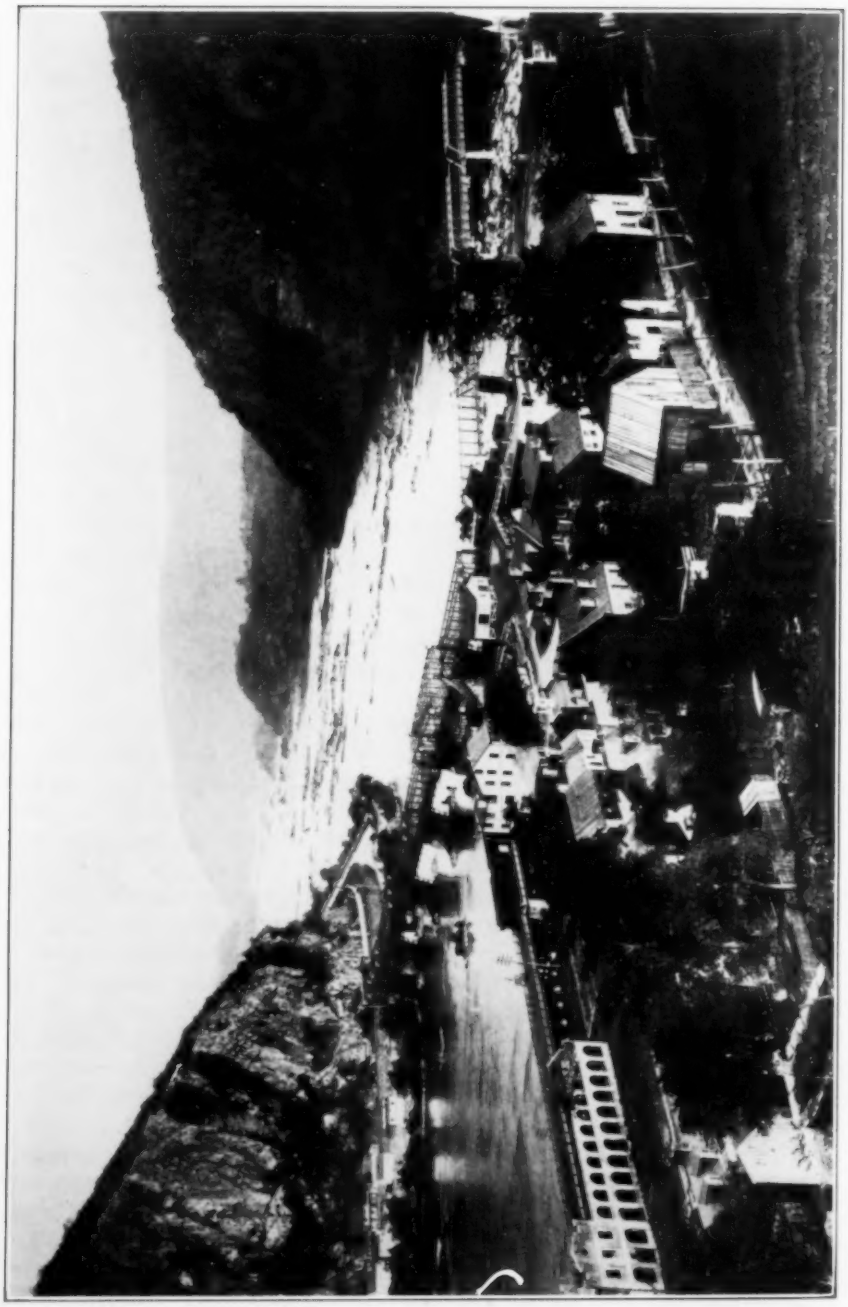


PLATE I. WATER GAP OF THE POTOMAC RIVER
THROUGH THE BLUE RIDGE AT HARPER'S FERRY. PHOTO BY FRANK SMART, U. S. GEOLOGICAL SURVEY

study in America this peculiar feature of Appalachian drainage has aroused much interest, and various explanations of the water-gaps have been advanced. Some observers offered the romantic explanation that during the deluge described in the Bible, when Noah and his Ark sailed the waters of the deep, great waves hurled gigantic boulders against the mountain barriers until openings were broken through them. Others believed that fracturing of the earth's crust, such as produces most of our earthquakes, made lines of weakness in the hard-rock ridges which rivers could then easily widen into the water-gaps as we see them. One author avoided the difficulty very neatly by by saying that rivers flowed along until they came to openings in the mountains, whereupon the rivers turned and went through these openings. Apparently in his mind the water-gaps were like Topsy —they "just growed" that way. A more complicated explanation, and one accepted in earlier days by many geologists, supposed that the rivers acquired their present courses long before the mountains came into existence. Then the earth's crust was wrinkled so very slowly that the rivers were able to cut down their channels just as fast as the mountains were uparched across their paths. The majestic gorge of the Columbia River through the Cascade Mountains, the Royal Gorge of the Arkansas in the Rocky Mountains (Plate II), and even the Grand Canyon of the Colorado in Arizona have by some been explained in this way. According to this theory the rivers are very much older than the mountains they cut across.

It is very true that rivers are often among the very oldest features of our landscapes; and that the hills and mountains, although truly "rock-ribbed," as the poet tells us, instead of being "ancient as the sun," are relatively transient features of the earth's surface, often washed away completely in the course of time. But the geologist has discovered serious objections to the theory that Appalachian rivers are older than the mountain ranges across which they flow, just as he finds serious objections to all the other theories mentioned above. It is quite possible that no one has yet discovered the true explanation of the mysterious behavior of these rivers in flowing directly through one hard-rock barrier after another. But I venture to present the latest interpretation of this peculiar feature of Appalachian scenery, the one which seems best to explain all the facts known to us.

In outlining this latest theory one must go far back in earth history and repeat some things upon which all geologists are agreed: Where the Appalachian Mountains now stand there was, millions of years ago, a great shallow sea, stretching far westward to and beyond the position of the present Rocky Mountains. Rivers brought gravel, sand and mud from adjoining land masses to deposit them in this shallow ocean basin, and lime was deposited from the oceanic waters. At times the deposits filled parts of the vast basin, changing such areas into extensive plains on which the rivers continued to spread their deposits, and over which extended broad swamps filled with beautiful tree ferns and other tropical vegetation. The gravels, sands, muds, lime and swamp deposits, when hardened and otherwise altered, became the conglomerates, sandstones, shales, limestones and coal beds which we find in the Appalachian region to-day. In the shales and limestones are abundant marine shells of very ancient pattern; and in the coal beds, trunks and roots of trees, and graceful impressions of the fronds of ferns.

Then came a great change. The long repose of the inland sea and plain gave place to a slow but relentless crushing of the earth's crust. From southeastern

PHOTO BY FRANK SMART, U. S. GEOLOGICAL SURVEY

PLATE II. ROYAL GORGE OF THE ARKANSAS RIVER

A GATEWAY CUT THROUGH ONE OF THE ROCKY MOUNTAIN RANGES IN COLORADO. ACCORDING TO ONE THEORY, THE RIVER WAS HERE FIRST. THE MOUNTAIN RANGE WAS LATER UPLIFTED ACROSS ITS PATH, BUT SO SLOWLY THAT THE RIVER WAS ABLE TO CUT DOWN AS FAST AS THE MOUNTAIN MASS WAS UPARCHED. PHOTO BY DOUGLAS JOHNSON.

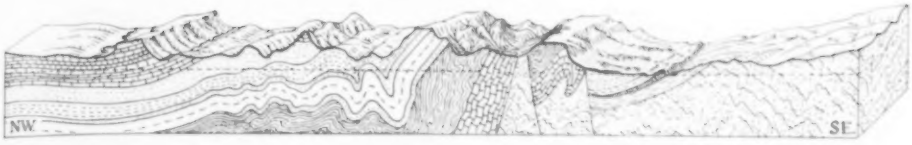


FIG. 1. A SLICE OF THE EARTH'S CRUST

CUT ACROSS THE APPALACHIAN MOUNTAINS AS THEY ARE SUPPOSED TO HAVE APPEARED MANY MILLIONS OF YEARS AGO.

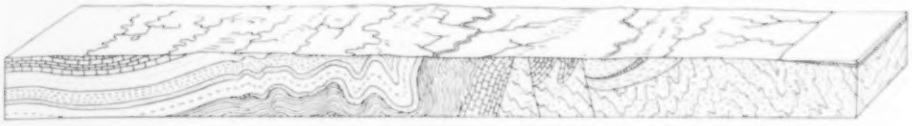


FIG. 2. THE ANCESTRAL APPALACHIANS

AS THEY APPEARED AFTER MILLIONS OF YEARS OF STREAM EROSION HAD REDUCED THE MOUNTAINOUS REGION TO A LOW-LYING PLAIN NEAR SEA-LEVEL.

FIG. 3. THE FORMER MOUNTAIN REGION

IS COVERED BY THE ADVANCING SEA, AND BY THE DEPOSITS OF SAND AND MUD ACCUMULATING ON THE SEA BOTTOM.

FIG. 4. THE APPALACHIAN REGION

IS RAISED OUT OF THE SEA, AND A NEW SYSTEM OF RIVERS FLOWS SOUTHEASTWARD (TO THE RIGHT) DOWN THE SLOPING SURFACE OF THE SEA-BOTTOM DEPOSITS.

FIG. 5. THE PRESENT APPALACHIANS.

THE SEA-BOTTOM DEPOSITS HAVE BEEN REMOVED BY EROSION, EXCEPT FOR A REMNANT AT THE SOUTHEASTERN (RIGHT) END OF THE SECTION. RIVERS HAVE ERODED VALLEYS ON WEAK ROCKS, LEAVING HARD ROCKS STANDING UP AS MOUNTAIN RIDGES. THE MAIN RIVER PERSISTS IN THE COURSE EARLIER ACQUIRED (FIG. 4), CUTTING WATER-GAPS THROUGH THE RIDGES.

PLATE III. WIND-GAP NEAR PEN ARGYL, PENNSYLVANIA

IT IS BELIEVED THAT THE UPPER PART (NORTH BRANCH) OF THE SUSQUEHANNA RIVER FORMERLY FLOWED SOUTHEASTWARD THROUGH THIS GATEWAY, WHICH IS NOW ABANDONED BY THE STREAM THAT CARVED IT. PHOTO BY DOUGLAS JOHNSON.

Canada to the Gulf of Mexico a broad belt of the former sea and land deposits was upheaved and thrown into gigantic folds or wrinkles, the ancestors of our present Appalachian Mountains (Fig. 1).[1] Down the slopes of these mountains, and along the hollows between them, the falling rains collected in brooks and rivers. We shall not concern ourselves with these very ancient river courses because, according to our best evidence, all these streams were later completely destroyed, and have nothing whatever to do with the present courses of Appalachian rivers.

If you ask the geologist when it was that the flat-lying beds of the inland sea and plain were crumpled up to form the Appalachian Mountains, he can tell you on the basis of abundant reliable evidence that it must have been many, many millions of years ago; probably somewhat more than 200 million years, although he can not fix the time with any degree of accuracy. But he knows it was so extremely long ago that the rains and rivers, each day washing some small part of the mountains into the sea, had ample time to wear all the high ridges of the ancestral Appalachians down to a low plain near sea-level. The rivers still persisted on the low plain, but only the roots of the mountain folds were left (Fig. 2).

Then occurred the most dramatic event in the long history of the Appalachians, an event which, as we shall see, explains the mystery of the water-gaps. Slowly the low plain was bent down under the sea to the east. Slowly the

[1] All diagrams used in this article are from the author's volume on "Stream Sculpture on the Atlantic Slope," and are reproduced by the permission of the publisher, Columbia University Press, New York City.

Atlantic Ocean crept in over the down-bending plain, past where Boston, New York and Atlantic City now stand; past the present positions of Albany, Philadelphia, Baltimore, Washington and Richmond; still further west, far past Harrisburg, Harper's Ferry and Charlottesville, Virginia; so far west, indeed, that most of what had been the mountainous region was now covered by the sea (Fig. 3). Where the rivers formerly flowed, now rolled the ocean waves. The entire drainage system of the early Appalachians was blotted out completely, and the roots of the ancient mountain folds were buried under deposits of sand and mud laid down on the new sea floor.

Again conditions changed. Slowly the sea bottom, with its deposits of sand and mud, was raised out of the ocean waters, with a strong slant downward toward the southeast. On this slope an entirely new series of rivers was born (Fig. 4). Since the upraised sea bottom was inclined downward toward the southeast, the rivers flowed in parallel courses down this slope; that is, from northwest to southeast. The steeply tilted hard-rock layers were, of course, still left in the roots of the old mountain folds. But since they were completely buried under the new sea-bottom deposits of sand and mud, they could not in any way influence the new drainage system. Thus it happened that while the hard-rock layers underground all trended from northeast to southwest, the rivers developing on the overlying cover of sea-bottom deposits all flowed in exactly the opposite direction, from northwest to southeast across the buried ridges.

The rest of the story is easy to understand. The rivers cut deeper and deeper into the cover of sand and mud, until they found themselves flowing across the hard-rock ridges below. Once starting to cut in that position, they could not easily change their courses, and so continued to cut deep notches into the resistant rock. Meanwhile, further erosion washed most of the cover of sand and mud back into the sea. Branch streams developed on the weaker layers of the underlying folded rocks, and wore them down much lower than the hard-rock ridges. The main streams continued their original southeast courses across the mountain barriers, and the notches cut by them became known as "water-gaps." Even where a main stream has since been diverted to some other course by important geological events, its former pathway across the mountain barrier is often clearly marked by a "wind-gap" (Plate III). A wind-gap is a notch or gateway similar to a water-gap, except that the stream which carved it no longer flows through it.

We have, I think, found a reasonable solution for the mystery of Appalachian drainage. It explains why the mountain ranges have one direction, and the main rivers an entirely different direction. It explains why the mountain ridges are found to be merely the stumps of great folds, which formerly rose many thousands of feet higher than the ranges we actually see to-day. And it explains how the rivers could cut spectacular gateways through the very hardest rock in these mountains. Delaware Water Gap, and other water-gaps of the Appalachians, are not merely forms of exceptional scenic beauty. They have the added charm of an origin dating millions of years back in the remote geologic past, and testify to sweeping changes of land and sea during a history full of truly marvelous events.

THE CHACHAS OF ST. THOMAS

By Dr. EARL B. SHAW
DEPARTMENT OF GEOLOGY, SMITH COLLEGE

ALMOST every visitor to the United States Virgin Islands is interested in the small group of white French Chachas[1] who live in St. Thomas (Fig. 1). These fisher and farmer folk furnish such a contrast to the large colored element in the population that one can not help being curious about who the Chachas are, where they came from and what they are doing on an island which belonged to Denmark for over two centuries and only sixteen years ago was purchased by the United States. It is the purpose of this article to answer these questions and to indicate the influence of geographic environment on the manner of living and occupations of this little French colony.

The Chachas are a group of French peasants, numbering about nine hundred, who form a separate and distinct element in the life of St. Thomas. They differ from the colored people, who make up 87 per cent. of the inhabitants, in race, language, customs and major occupations. With their tanned ruddy faces the French stand out conspicuously among the large number of black Negroes. When one hears the Chacha speak, the French patois[2] serves to emphasize his distinctiveness, for the language sounds strange after listening to the colloquial English of the colored. Customs set the French apart even more definitely. Unlike the Negroes, members of the little colony have married only with their own clan and have kept their racial purity for generations. This characteristic is an unusual one in the West Indies; in fact, white colonies who have maintained the purity of their race through a long period of time are far from common in any section of the tropics. Finally, one group of the French colony account for most of the fishing of St. Thomas; they are good fishermen and boatmen, and although most of their canoes are crudely made, the Chachas handle their craft well and one seldom hears of accidents. The other group of French are farmers. They make their living under trying conditions; all their land is in slope, and some of it is so steep and stony that one wonders how the farmer engaged in tilling the soil can keep his balance.

Different stories are told of the Chacha emigration to St. Thomas. It has been said that they are descendants of French Huguenots who fled to the Virgins after the revocation of the Edict of Nantes. La Bat,[3] an early French writer on West Indian lands, indicates that in 1701 two small streets in St. Thomas town were occupied by a group of French refugees. The group to whom La Bat refers were no doubt Huguenots, for a few descendants of these trades people, who always lived in the port of St. Thomas, yet remain. These descendants, however, are not Chachas, and the fact that all Chachas are Catholics throws extreme doubt on any story that their ancestors were early French Protestant emigrants. Another tale suggests that their ances-

[1] The French received their name from the Negroes. The English-speaking colored people could not understand the French patois and indicated that it sounded like "chacha" to them. That name has clung to the French ever since in spite of their dislike to it.

[2] Many of the Chachas speak and understand English as well as French.

[3] Pere La Bat, "Voyage aux Isles de l'Amérique," Vol. II, p. 285.

tors came from St. Croix after the French sold the island to Denmark in 1733; this seems improbable, for the French deserted St. Croix in 1695 and, after burning their houses, sailed for Santo Domingo. A final version indicates that the Chachas are descended from French people who left the islands of St. Bartholomew and St. Kitts after the middle of the nineteenth century, and came to St. Thomas because they thought they would better their economic situation by the change.

It is known that in 1866 two young Frenchmen by the name of La Place sailed from St. Barts and settled on the north side of St. Thomas.[4] Others came from the little French island later and the descendants of these emigrants make up the agricultural Chachas to-day. Moreover, there is authentic evidence that many of the fishing colony came from St. Bartholomew or are descendants of emigrants from St. Barts. In fact, reliable authority makes safe the assumption that all Chachas are descendants from colonists who came from Brittany in early days and settled on St. Barts and other French Caribbean isles before coming to St. Thomas less than a century ago.

[4] Joseph A. Kimm, "Mafolie," *The Angelus*, November, 1931, Baltimore, Maryland.

The Chacha Fishermen

The fishing group who live at Carenage, a suburb of St. Thomas adjoining the city on the west, came from a long line of fishermen. Before leaving Brittany for the Caribbean, the European ancestors of the Chachas no doubt gained some of their living from the sea. Their occupation was encouraged by a plentiful fish supply in near-by waters, numerous bays and inlets of a submerged coast-line which provided fishing bases, and the lack of favorable economic opportunities on land. When the Bretons came to St. Barts, again physical factors guided several into the fishing

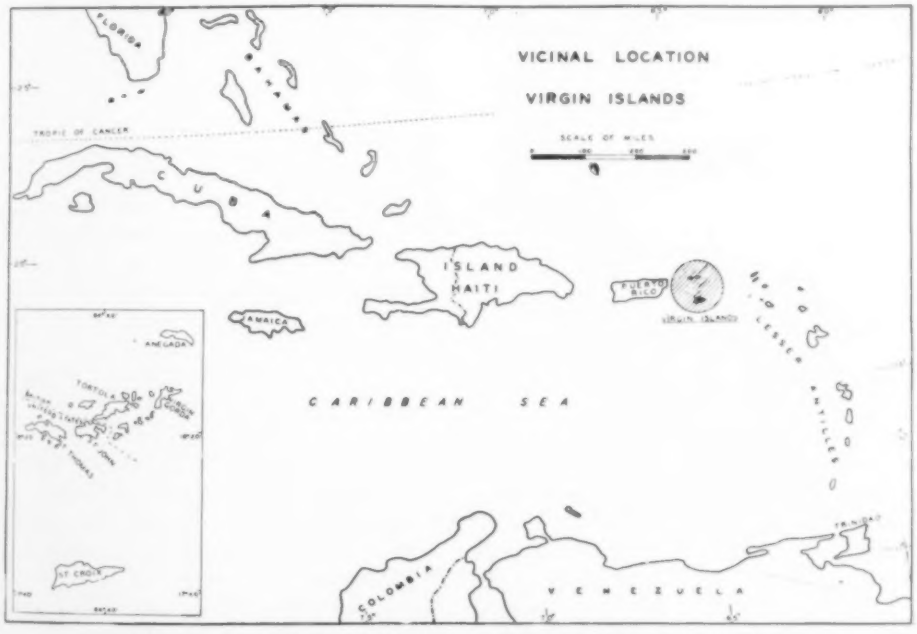


FIG. 1. VICINAL LOCATION OF THE VIRGIN ISLANDS

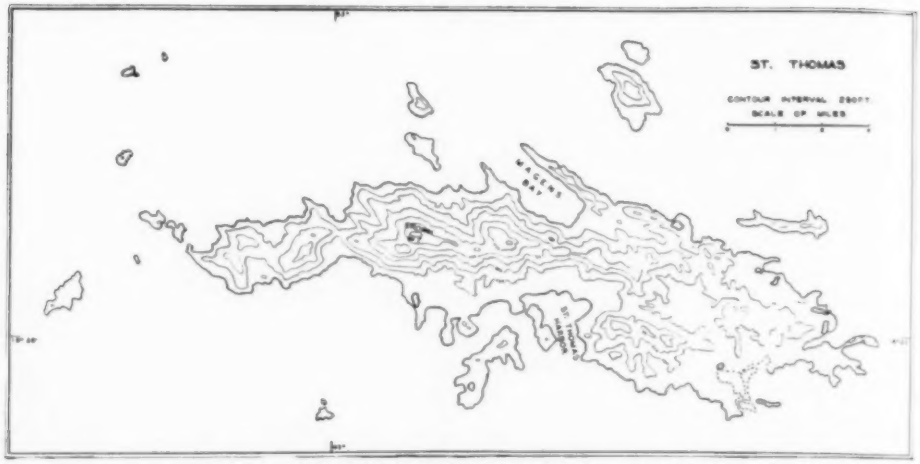


FIG. 2. TOPOGRAPHIC MAP OF ST. THOMAS

industry. The rugged topography and inadequate rainfall discouraged farming, while submarine banks surrounding the island provided an ideal environment for fishing. Finally, when the descendants of the Brittany emigrants left St. Bartholomew and sailed for St. Thomas many continued to follow the industry of their fathers because the indented shore-line, the wave-cut shelves, the submarine platform and an inhospitable environment for farming—all were features that called the new Virgin Islanders to the sea.

To-day the French use the little bay fringing their town of Carenage, a suburb of St. Thomas, as a fishing base. From here they row and sail their small boats throughout the banks area which extends seaward for several miles from the shore-line of St. Thomas. In fact, the submarine platform upon which St. Thomas rests is merely a portion of the larger platform that supports Puerto Rico, Vieques, Culebra and all the Virgin Islands, with the exception of St. Croix. The water above this bank and the wave-cut shelves which bound its inner margin is comparatively shallow; and the slight depth aids in the mechanics of fishing. Moreover, an abundance of sunlight penetrates to the shallow submarine floor, and provides a necessary element in the formation of plankton which gives food for the fish. The numerous bays and inlets of the submerged coast furnish storm protection for the fishermen and make easy the capture of fish, many of which seek the quieter waters. The forest vegetation, found on parts of St. Thomas, affords materials for fashioning traps, trap marker buoys, buoy lines, turtle decoys, a few of the boats and some of the other equipment used by the workers. The local vegetation also supplies a portion of the bait for attracting the catch. Finally, the steady trade winds drive the semi-sailboats on one leg of the fishing journey. These major geographic factors aid the fishing of the Chachas.

The Chachas peddle most of their fish from house to house and sell them by the strap. The strap, a piece of heavy grass or reed, takes the place of a string; and French fishermen with several bright-colored fish strung on these reeds may be seen on the streets of St. Thomas almost any time of the day. The price varies with the hour of sale—in the

morning it is higher than in the afternoon; for in a warm climate the fish deteriorate rapidly without ice, which the Chachas find too expensive to buy.

Fishing does not yield enough income to provide a fair standard of living. Hence, the women folk weave certain of the indigenous palms and grasses into attractive basketry, hats, mats, brooms and other articles and sell their handiwork to local buyers and tourists. Even with this supplementary income some families lack sufficient means for the necessities of life; and rumor goes that several of the men resort to "bootlegging" in order to add to their meager funds. "Bootlegging" should not be a difficult occupation in St. Thomas. The source of liquor is near—Tortola, a British island a few miles to the northeast, is "wide open"; the numerous bays and inlets of the submerged shore-line provide good hiding places from prohibition agents; and the people of St. Thomas hold the eighteenth amendment in no greater awe and reverence than do people in continental United States. All these factors would favor any Chacha who dared supplement legitimate with illegitimate occupation.

The Chacha Farmers

Crop agriculture is a hard taskmaster in St. Thomas, yet three or four hundred Chachas gain the major share of their income by this type of farming. St. Thomas has a very rugged topography; a mountain backbone extends in a general east-west direction throughout the island's length, and north-south spurs branch from the axial range in several places—in some areas reaching the coast (Fig. 2). Probably not more than four or five hundred of the total of eighteen thousand acres could be called arable. Upon this topographic background, and with thin soils affording little agricultural aid, the industrious French produce their crops of vegetables and fruit. In spite of the slight encouragement that nature has given them on land, they have chosen a money crop there rather than risk the harvest of the sea, like the Chachas of the port city. True, the north side French supplement their farming by sustenance fishing, but crop agriculture remains their major occupation, and terracing, necessary in some places, calls for intensive culture. However, the gardens do not involve the terracing of entire hillsides, as is the case in some parts of the world where steep slopes of hundreds of acres are cultivated by patient workers; but here small plots containing fifteen or twenty terraces, each several rods long and a few yards wide, spot the general background of woodland vegetation.

Geographic factors have influenced the choice of farm location. Limited

FIG. 3. ROCKS IN CHACHA GARDEN

THE FARMER HAS CLEARED THE VEGETATION FROM HIS LAND, BUT HE MUST YET PILE ROCKS AND TILL THE GROUND BEFORE PLANTING.

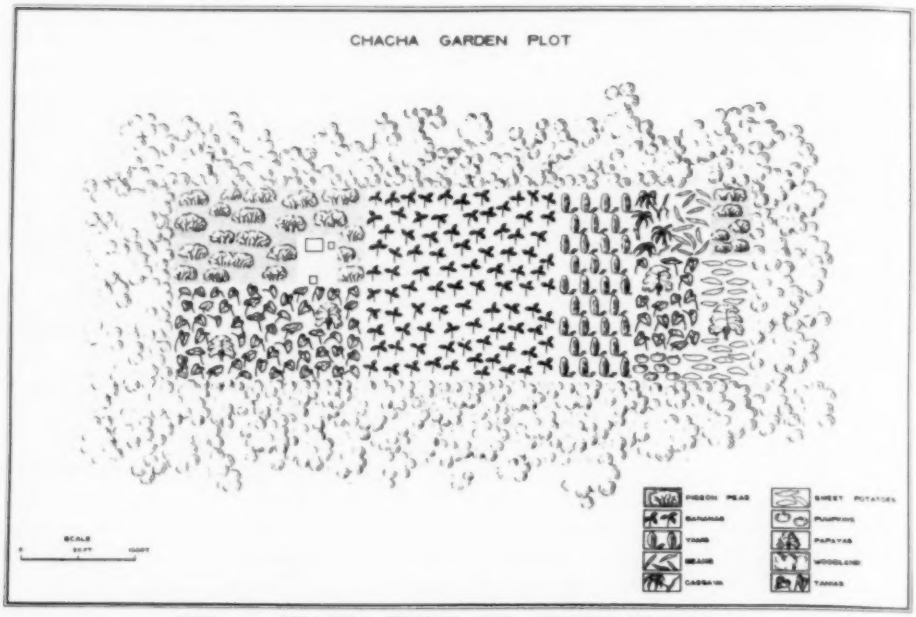


FIG. 4. CHACHA FRUIT AND VEGETABLE PLOT

moisture has always been a significant handicap to agriculture in St. Thomas as well as in the other Virgin Islands, so that the thrifty farmer is careful to locate where maximum precipitation occurs. Northern instead of southern slopes are chosen, because the former lie to the windward of the northeast trades, and where elevation is sufficient there is a noticeable advantage in rainfall. Furthermore, the north slope permits less exposure to the sun, an important factor in an area where evaporation is as high as it is in this trade wind zone. The farms are not favorably situated in reference to the St. Thomas market, but the moisture advantage outweighs the handicap of distance.

None of the land is suitable for machine cultivation, as mechanical equipment does not work well on land with a high angle of slope and on ground that is covered with stones (Fig. 3). Moreover, the small size of the plots and the poverty of the farmers are also limiting factors. Here and there boulders of several tons defy removal, but the worker picks off the smaller rocks and uses them in his terracing. However, he must clear off the brush growth before piling the stones; so with the machete, the all-purpose tool of the Caribbean, the first stages of gardening begin. After the vegetation is removed and the outer edge of the terraces buttressed, each rock-bordered plot is given a thorough preparation before any seed are planted. The machete is not discarded entirely in making ready the seed bed, but the versatile knife yields its importance to a heavy mattock-like hoe, better suited to removing roots and tilling the soil.

Planting may take place at any time of the year, although February, March and April are the months of lightest rainfall; few farmers risk this dry season to start crops except near the close of the period. During the early summer, convectional rains usually provide

ample moisture for the fruits and vegetables, and in late summer and fall the hurricane influence furnishes bountiful precipitation.[5] A variety of crops are grown, and when the ground is covered with vegetation the little farm looks like a miniature patchwork quilt (Fig. 4). The Cavendish banana, which is grown in preference to the Gros Michel or other large species because of the lesser moisture requirements, occupies about one third of the space. There is a tendency, where possible, to utilize low-lying ground in order to take advantage of greater water supply and the fresh soil materials that are washed down from steeper slopes above. Terracing is seldom practised in raising bananas. Root crops take a large share of the remaining area; first among these are tanias (Fig. 5), tropical tubers which taste like potatoes, although the large elephant-eared leaf has no resemblance to the potato vine; second, one may see the sweet potato, a drought-resistant vegetable well adapted to St. Thomas environment; following in order are pigeon peas, yams and cassava, with smaller areas of onions, tomatoes, egg plants, peppers, okra, turnips, cabbage and lettuce. Not all crops are grown by each farmer, for the last named vegetables are not easy to raise; yet no garden is without tanias, bananas, sweet potatoes and pigeon peas. Very few Chachas attempt growing corn. Although a critical influence, deficient moisture, is not the limiting factor; instead, diseases and insect pests, which are a problem in raising nearly all tropical crops, so handicap the maize that the French have given up its planting. It is not necessary to distribute crops, so that tall bushy plants like pigeon peas occupy sections to the windward of the garden. This custom is followed in many places of the tropics where vegetation has been cleared over large areas; but here a general background of second growth woodland protects the garden spots from the desiccating effects of the northeast trades.

Marketing offers almost as many problems as production. There is little opportunity for export, as size of industry, lack of standardization and quality of produce, inadequate transport and storage and keen competition from regions with better physical backgrounds restrict outgoing shipments. Furthermore, the neighboring islands of St. John and Tortola (British) compete for the one home market, St. Thomas City. Finally, since the Chacha gardens are from three to five miles to the north of St. Thomas on the other side of the mountain range, delivery is by no means a simple task. The distance would be negligible were topography smooth and good roads available; but the highways are steep, rugged mountain trails, best fitted for donkey transport; and these little animals may be seen every day carefully picking a path along the narrow rocky way which leads from farm to market (Fig. 6). A boy[6] is usually hired to attend to the delivery and sale of the produce; the farmer has little time himself, for the task involves the greater part of the day, and he must keep busy tending his crops. Moreover, help may

[5] Sometimes rainfall is too heavy for these steep slope gardens. The writer visited this section on one occasion after an extremely heavy downpour, and the storm had played havoc with many of the terraces, the water washing large gullies through the cultivated land. The industrious French were zealously repairing the damage as best they could.

[6] The boys have peculiar signals which they employ to control the donkeys. One sounding like the yodeling of a "b'rrr" is the queerest the writer has ever heard. He met a pack train guided by one of the Chacha boys at a narrow section of the mountain road to St. Thomas one day. The lad called out a yodel that, while mirth-provoking to the listener, was very effective as a command, for the donkeys immediately turned the way the driver desired them to go.

FIG. 5. TANIAS

THE TANIA IS A ROOTCROP HAVING AN EXTREMELY LARGE LEAF (THE VINE IN THE IMMEDIATE FOREGROUND IS NOT A TANIA VINE). THE HIGH ANGLE OF SLOPE OF THE CHACHA FARM MAY BE SEEN IN THIS PICTURE.

be obtained cheaply, especially at the present time when unemployment prevails in St. Thomas just as it does almost everywhere else throughout the world. Yet the same situation that brings about a plentiful labor supply encourages low prices for produce, and after paying his hired help, the farmer has a shockingly small amount left.

When prices are too low, the Chacha gardener turns to the sea, although he seldom, if ever, depends on fishing except for local sustenance. Some supplement crop raising by keeping a few chickens,[7] which furnish a desirable food supply and provide a surplus of eggs. These are carried to market in grass-packed baskets, a striking contrast to the modern egg case of the continental United States poultryman. On a few farms cows add to the family income. Donkeys, so useful in delivering fruit and vegetables, transport the milk to the city where it is peddled from house to house.[8]

Thus by versatility and hard work the Chacha gardener manages to make a living in spite of many handicaps. Moreover, his natural French thrift enables him to save money out of the small returns from his produce. In fact, several have bought their own land, and only a few years ago a company of thirteen purchased a tract of nearly three hundred acres. Contrary to general real estate practise, the purchasers paid for the whole in cash—in bills, silver and gold which they had taken out of hiding place—in earnings which they had been accumulating for years. The ground, the house or some similar hoarding place is the Chacha "bank." They have little faith in banking institutions and point to a recent local failure to justify this feeling. However, French "safety boxes" are not exactly secure; for at times when hurricanes have destroyed their houses these banks disappeared with the storm.

CHARACTERISTICS COMMON TO BOTH FISHER AND FARMER FOLK

Chacha Houses

The houses of the Chachas are not gorgeous mansions like the luxurious "great houses" of the early colonial sugar planters. In fact, some people might characterize the little French

[7] Chickens are hard to raise, however, for the mongoose takes a heavy toll. This animal was brought to the island to rid it of snakes and rats, but has proven as great a pest as the creatures which he has eliminated.

[8] Early in the morning donkeys loaded with boxes of bottled milk, a box on either side and a boy seated in the middle with his legs dangling over the animal's neck, may be seen on the streets of St. Thomas. The unpasteurized milk is sold in long-necked bottles with stoppers made from leaves.

dwellings as shacks, although the majority have a neat well-kept appearance in spite of their small size and modest construction. In general, they are built of wood and covered with galvanized roofing, a roof type quite common in the Caribbean region. With but two or at most three small rooms and no cellar or basement, the Chacha homes provide little extra space for the large families so characteristic of these people.

Simple in plan and construction, all houses are kept scrupulously clean. The Chachas zealously practise the precept that cleanliness is next to godliness, and they neglect neither of these characteristics. Cleaning is simplified by the fact that there are no carpets to sweep, no rugs to beat and no windows to wash. A special house cleaning is administered just before Christmas and the walls, generally covered with newspapers and religious pictures, are decorated with fancy garlands which are left up until well into the next year. The French rely on local resources for many of their household necessities. The maran, *Croton astroites*, provides soap; the skin of an alewife fish makes a good substitute for a scrub brush; and the leaves of indigenous palms furnish materials for brooms and mats. Local environment also contributes to their furniture. A few of the well-to-do may have a mahogany four-poster bed. Both bed and mattress may be made from island vegetation—the bed from the mahogany trees, which now have almost disappeared, and the mattress from bed grass or from the widely used banana leaves which yield ideal packing when dried and stemmed. But four-posters and mattresses are only for the more prosperous, and the rank and file have simpler bedroom furnishings. Father and mother may sleep in a bed, but each child, and often the parents, sleeps in a simple hammock made out of fish net material without even a bar piece at the head. A few chairs, a plain bench and perhaps a small table make up the remaining furniture.

Chacha Food

Like the house and furnishings, the food and manner of cooking is relatively plain and simple. Most families prepare their meals in charcoal pots placed on the dirt floor of an outside kitchen, or resting on three stones just beyond the house. The stones may be obtained easily anywhere, and the charcoal may be made from wood secured from the cutover forests. The preparation of the meal outside the house, a custom characteristic of most families of the Virgin Islands, saves the living quarters from heat and the odor of cooking food.

FIG. 6. CHACHA WITH DONKEYS LOADED WITH PRODUCE

THE DONKEY IS THE CHACHA'S "DELIVERY WAGON." THESE SURE-FOOTED CREATURES ARE WELL SUITED FOR THE TRAIL TRAVEL BETWEEN FARM AND MARKET. THEY TAKE BUT LITTLE CARE AND FEED AND ARE NOT SO PARTICULAR ABOUT THEIR FOOD AS THE HORSE.

The meals of the fisher folk consist mainly of fish, fungi,[9] and "soups" and "teas" often made from indigenous plants. The farmers, however, have a better balanced diet. They may eat fish and fungi, but all have fruits and vegetables and some have milk and eggs. This variety gives them a nourishing ration, which is reflected in the more robust appearance of the agriculturist class. In eating their food, the organized family meal, which is common within continental United States, is extremely unusual. In general, Chachas eat separately; one may eat on a bench, another on the doorstep, and others may stand or sit in the yard while eating their food. They almost never congregate at a table for a meal, but carry their own little bowl[10] or plate around with them and help themselves from a common vessel of food.

Chacha Clothing

The clothing of the Chachas would distinguish them from the rest of the population, even though other differences were lacking. The women pay little attention to the whims of fashion, and consistently wear calico gowns and petticoats which reach well down to the ankles. The "cotta" and the kerchief, characteristic features of the Negro dress, are missing from the Chacha women. The French do not need the "cotta," for they seldom carry a head load, and they will have none of the big kerchief around their shoulders. On their heads the Chacha women wear high-crowned, home-made straw hats, broadly banded with black and carrying a narrow drooping brim. The men are also dressed in neat, clean, simple attire. The hats, while showing masculine features, do not differ greatly from the high-crowned straws of the women. Furthermore, the straw headgear, fashioned by hand from the indigeous grasses and palms, matches well with the clean, colored shirts and narrow-legged pants or overalls which make up the remainder of their attire.

[9] Fungi is a gruel made largely out of cornmeal. The meal is imported, for it can be shipped in cheaper than corn can be grown and prepared.

[10] Some eat their meal from calabash containers, which may also be used for drinking cups. The calabash is an indigenous tree, *Crescentia cujete*.

Chacha Religion

All Chachas are religious. The fishing colonists attend a Catholic church situated in the higher part of their little town of Carenage. The agriculturists recently built a chapel near Mafolie estate to the north of the port and near the crown of the mountain divide. Both buildings are modest structures, and the severely plain benches and latticed altar rails carry out the idea of simplicity so characteristic of the community. The French children go to Catholic schools, although ample facilities are available at public institutions. In fact, on the north side some of the Chachas walk a mile or more past a public school on to the Catholic chapel and school at Mafolie.

Conclusions

In spite of an environment endowed with few economic opportunities, the industry, patience and thrift of the Chachas enable them to make a modest living. The similarity in physical background between several features of Brittany, St. Bartholomew and St. Thomas no doubt influenced the fisher folk to follow the occupation of their forbears. In carrying it on they made use of available geographical advantages—the banks, the inlets and harbors, the trade winds and the local resources that provide them with much of their fishing equipment. The harsh farming

conditions of St. Thomas, not dissimilar in many ways to those of St. Bartholomew and Brittany, have failed to daunt the agriculturally inclined workers. They too have been guided by geographic principles in their arduous work. The location of their farms on the windward side of the mountain, the distribution of the crops in their gardens, the buttressing of the terraces with the plentiful supply of stones and the utilization of animals adaptable to the marketing of their produce—all indicate a tendency to take advantags of local geographic resources. Further geographic adjustments may be seen in the Chacha mode of living, in the character of their house, food and clothing: the plainness of their dwellings is a response to limited economic opportunity; their food is sharply influenced by their occupations and island resources; and the simpleness of their attire is an outward expression of their simple frugal life.

Unlike the Negroes, the Chachas offer few problems to the United States Government. If all the people of St. Thomas were as industrious as the French, the island resources would yield to a maximum; if the colored people were as thrifty as the Chachas, fewer favors would be asked of a paternal government; if the sex morality of the Negroes were as strict as that of the French, there would be less illegitimacy and a smaller percentage of mixed population. In short, the Chachas afford a constructive example to both natives and outsiders. They have made a living in a hard environment by means of pluck and hard work and with little help from outside; and they have maintained rigid sex standards and racial purity in the tropics—a task some believe impossible.

THE INTERNATIONAL STATUS AND OBLIGATIONS OF SCIENCE[1]

By Dr. A. V. HILL, F.R.S.

FOULERTON PROFESSOR OF THE ROYAL SOCIETY

In 1796, Britain being then at war with France, a French scientific sailor, Chevalier de Rossel, a prisoner of war in England evidently on parole, dined with the Royal Society Club in London on the invitation of Alexander Dalrymple, the hydrographer to the Admiralty. The Navy, as well as the Royal Society, clearly regarded scientific standing as entitling its holder to civilized and friendly treatment, regardless of the misfortune of a state of war between the two countries.

Among the instructions issued by the Admiralty to the captain of H. M. S. *Rattlesnake*, in which Huxley sailed in 1846 as "a surgeon who knew something about science," was the following:

> You are to refrain from any act of aggression towards a vessel or settlement of any nation with which we may be at war, as expeditions employed on behalf of discovery and science have always been considered by all civilized communities as acting under a general safeguard.

These short extracts from relatively modern history provide a text for this lecture. Science and learning have for several centuries been regarded by all civilized communities as entitling those who follow them to a certain immunity from interference or persecution—provided that they keep to the rules. You will notice that in both instances the Admiralty appears; they were chosen particularly for that reason. Sailors are apt to be friendly and chivalrous people, but also they realize—as the Admiralty has realized in its long association with the Royal Society of London—that such practical matters as lives and ships depend in some degree upon science, discovery and invention. In the second place, I would emphasize that this view of the position of science in the world at large does not involve any lack of pride in, or affection for, one's own country, that there is in fact as much to say for it from the point of view of old-fashioned chivalry as from that of modern internationalism. Science is a common interest of mankind: whatever the barriers or the difficulties or the struggles between them, civilized societies have accorded a certain immunity and tolerance to people concerned with scientific discovery and learning.

Why should science be singled out in this way? Merely by an ancient privilege based on an aristocratic and capitalistic tradition? Certain Russian colleagues, attending an international congress in London in 1931 on the history of science, made a vehement and mass protest against the claim that the progress of scientific ideas as such deserves a better place in general historical study. According to them science must be regarded not for its own sake but simply as the handmaiden of social and economic policy; probably they would protest even more vehemently against my present claim that in a certain sense science and learning are superior to and above the state. I would not, as a matter of fact, be ashamed to base an argument in part upon an aristocratic idea, for in science all men are not equal, any more than they are in strength, in courage or in goodness; but although histor-

[1] Huxley Memorial Lecture, Birmingham, November 16, 1933.

ically privilege may have had something to do with the tolerance shown to science, there is a much better reason for the safeguards given it by decent nations. The reason is that its methods of thought, its direct appeal by experiment to a universal nature, the new powers given to mankind in general by its application, so obviously do not depend upon the opinions, or emotions, or interests of any limited group that any civilized people will admit that it transcends the ordinary bounds of nationality. Religion, literature, art depend in part upon customs, emotions, race, climate, age and sex. The religious instinct, the artistic sense, may be universal enough, but their expressions can be so different that they may lead sometimes to strife rather than cooperation. In science, however, although mistakes are common and much that is published had better have been burned, although controversies are frequent and deplorable, although vanity and self-interest may hinder scientific progress as they may any other form of human endeavor, one fact remains certain. As all who are acquainted with the history of science and its present world position know, its discoveries do gradually build up a structure which is approved by all sane men; in the last three hundred years the experimental method, which is universal, has produced results beyond all previous human achievements. It is this universality of its method and results which gives science a unique place among the interests of mankind.

Science may be grossly misapplied, whether in making poison gases for war or in poisoning the decent sense of mankind. There are biologists who believe, or speak as though they believe, that the only effective biological principle is that of the "survival of the fittest." Following this narrow creed, a year or two ago Sir Arthur Keith delivered a rectorial address to the students at Aberdeen in praise of hatred and "prejudice" and in exaltation of war as a biological process. There are professors of war in Germany who do the same to-day, appealing in their case to historical and not to biological myth. It is sad that the tribal prejudices of so sweet and humane a nature as Keith's should tend to bring science into contempt, to remove the just basis for its privileged position: for biology does not teach what he supposes it teaches. Any physiologist who regards the living animal as a whole, after surveying in detail the functions of its several parts, is impressed by the extraordinary extent of coordination of those parts and functions. The further he explores the more intricate and perfect do the adjustments and adaptations appear. The differentiation of function, which has made the higher animals possible, has led to an extreme degree of cooperation between the different organs themselves, ensuring the well-being of the animal as a whole. The brain and the muscles, the pancreas and the liver, do not normally war against each other in order to ensure the survival of the fittest! What is true of a single creature is true also of a community: indeed, it is often impossible to say where individual ends and community begins. The chief principle, therefore, in biology, the principle which differentiates it fundamentally from physics, is that the living organism is stable and self-perpetuating, within wide limits of treatment or environment, owing not to incessant struggle, or tribal prejudice, but to the exquisite integration, coordination and cooperation of its parts.

When, therefore, a biologist wishes to draw a moral, or to preach a sermon, from the principles of his science, let him take this as his text, and not the crude old nonsense that war, national hatred and national prejudice are biological necessities: otherwise, not only will he give to others the occasion to stumble,

but he will bring himself and his colleagues and their biology into disrepute.

I have dealt with this example, and made this protest, at length, because it serves to introduce a moral. If scientific people are to be accorded the privilege of immunity and tolerance by civilized societies they must observe the rules. These rules could not be better summarized than they were 270 years ago by Robert Hooke. Among Hooke's papers in the British Museum, Weld records a statement, dated 1663, which was probably drawn up after the passing of the Second Charter of the Royal Society. It begins as follows:

> The business and design of the Royal Society is—To improve the knowledge of naturall things, and all useful Arts, Manufactures, Mechanick practises, Engynes and Inventions by Experiments—(not meddling with Divinity, Metaphysics, Moralls, Politicks, Grammar, Rhetorick or Logick.

and continues:

> All to advance the glory of God, the honour of the King . . . , the benefit of his Kingdom, and the generall good of mankind.

Not meddling with divinity, grammar or rhetoric! To avoid such meddling is one price the scientific man must pay for his immunity: not a very heavy one, perhaps, though times come, as at present, when it is difficult not to meddle with morals or politics.

Scholars and scientists possess varying degrees of capacity in practical affairs. One disadvantage of prominence in any calling is the fact that the world, at least its newspaper reporters, is apt to believe that the views of the prominent person are of importance in matters altogether unrelated to his special capacity. The views of Bernard Shaw the Jester are quoted on politics or science: Soddy, the Chemist, writes fantastically about economics: famous astronomers get entangled with divinity or metaphysics. No doubt it is to be desired that Shaw should take an interest in science and Soddy in economics: preferably a reasonable and not an emotional interest: my contention simply is that their views need not be taken more seriously than those of more ordinary people. The most distinguished of mathematical physicists of to-day, Einstein, recently proposed at the Albert Hall that a place where young mathematicians could work undisturbed might be found in lighthouses: one pities the poor sailors who would depend upon their lights!

Newton, shortly before his death, is reported to have said—it were well if others had the same modesty:

> I know not what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

It is true that many distinguished scientists have been men of great general capacity; a man of such capacity is likely to be distinguished at any task he undertakes. The converse, however, is certainly not true; many of the most important contributors to science have been extreme specialists—rather dull dogs: others have been dreamers, poets, artists, rather than men of broad understanding. Their views on general topics may be entertaining, but they demand no special attention.

Not meddling with morals or politics: such, I would urge, is the normal condition of tolerance and immunity for scientific pursuits in a civilized state. I speak not with contempt of these—indeed the scorn with which some superior people talk of such necessities of social existence as morals and politics seems to me intolerably childish and stupid. The best intellects and characters, not the worst, are wanted for the moral teachers and

political governors of mankind; but science should remain aloof and detached, not from any sense of superiority, not from any indifference to the common welfare, but as a condition of complete intellectual honesty. Emotion, entirely necessary in ordinary life, is utterly out of place in making scientific decisions. If science loses its intellectual honesty and its political independence, if—under Communism or Fascism—it becomes tied to emotion, to propaganda, to advertisement, to particular social or economic theories, it will cease altogether to have its general appeal, and its political immunity will be lost. If science is to continue to make progress, if it is to lead to the advancement and not to the destruction of human institutions, it must insist on keeping its traditional position of independence, it must refuse to meddle with, or to be dominated by, divinity, morals, politics or rhetoric.

It is not always possible to avoid such meddling—as the life of Huxley showed. Much of Huxley's time was spent in battling with prejudice, in countering the attacks which were made upon the freedom of science to come to its decisions solely on scientific evidence. The traditional views of divinity, metaphysics and morals, aided by the resources of rhetoric, appeared in array against the Darwinian hypothesis and against evolution in general. Huxley realized the necessity of insisting on the independence of science, on the need of eliminating all other considerations in coming to scientific conclusions; and he knew—what all good fighters know—that offense is the best form of defense. He carried the war into the enemy's country so effectively that—apart from the vested interest of anti-vivisection—there has been in Great Britain no attempt to persecute scientific research and opinion for half a century. The world, and his country in particular, owe to Huxley a great debt for the freedom he won for science and scientific thought.

Such freedom, however, though fairly and hardly won, is not a permanent and inevitable attribute of science. At intervals it has to be maintained by further struggle. Like all great achievements of mankind, unless there are some to watch and guard, it may be destroyed in a night. The attachment of certain branches of science to competitive industry, desirable enough within limits, if it went too far might lead to the control of such science by industrial interests. The necessity of science in modern warfare might in some future Thirty Years War give it a purely national instead of an international basis. Its use for propaganda might prostitute it before the world. The coercion of scientific people to certain specified political opinions, as in Russia, Germany or Italy, may lower the standard of scientific honesty and bring science itself into contempt. Economic necessity may—it already does—so force young men, for reasons of advertisement, to unnecessary and premature publication, that the international burden of scientific literature may become top-heavy and unstable with disastrous consequences. These possibilities must be watched, and from time to time some champion of scientific independence must stand out, like Huxley, to do battle for freedom.

The present emergency—it can not fail to be in your minds—is that of the scientists and scholars in Germany who have been persecuted, or dismissed, for reasons of race or of independence of opinion. We are witnessing to-day, all over the world but particularly in Europe, an extraordinary phenomenon, the growth of a peculiar kind of "nationalism." The word "nation" is old enough, but the thought—or rather the emotion—which it arounses now is new. Since the dawn of history Europe has had its tribes, its village communities, its cities, its confederations, its kingdoms, its republics, its empires. It is in the process of developing—in many cases rather of

inventing—its nations. Unfortunately, neither blood nor language nor religion, nor continuity of territory affords any basis for the definition of a nation, and many of the difficulties of Europe today are due to the impossibility of deciding which nation is which. Now nationalism, like love of family, is a good thing when tempered with reason. Nobody seriously grudges the Scot his little jokes about Scotsmen, or the Devonian his boasts about Devon; the Californian, the Virginian and the New Englander all have their local conceits and prejudices, but these do not prevent them from working together as reasonable beings. To make your town or community happier, wiser or more prosperous, is a decent and worthy ideal; as I hold, it is worthy to try to maintain the traditional hospitality of England to those in other countries who are persecuted for causes other than crime. When, however, nationalism leads to excesses of the kind we have seen in the last years, particularly in the last eight months, not alone in Europe, but all over the world, when violence and hatred are preached as its necessities by otherwise decent people, then indeed one begins to think of nationalism not as a pleasant virtue but as a hideous disease.

As a natural reaction, of course, to nationalism, we see internationalism developing. Internationalism needs no more to be flabby and without character than the puritanism of the seventeenth century or the movement of the nineteenth to abolish slavery. One needs not to have a low opinion of one's own country to appreciate the virtues of others. Those who dislike war most—as the students who went from our universities in 1914 showed—are often the best fighters. The tendency to internationalism is displayed in the growth of international law. International finance, if its operations were large enough, might tend to promote agreement rather than strife. Travel results, in general, in less ignorance and bigotry, though it must be admitted that there is a type of ignorance and bigotry which returns home even more ignorant and bigoted than before. In literature and art internationalism first made itself felt. To write the history of any literature would be impossible without account of its foreign indebtedness. If the phrase "the republic of letters" is appropriate, "the republic of science" merely expresses a commonplace. International congresses, international measures of natural constants, geographical and navigational data and to-day radio (though that, alas, can be used also for fostering nationalism) are signs of the common interests of reasonable people in different countries. It can only be a matter of time before engineering standards, currency, and even some social customs, are much more uniform than to-day.

Another tendency, fostered by the same conditions, is to religious and political toleration. Earlier in the lifetimes of some of us still comparatively young, progress in this direction seemed inevitable; persecutions had fallen out of fashion. Even the Jews, whose history for centuries had been full of blood and tears, whose name had been a byword and reproach, had been admitted to all the rights of citizenship in all civilized countries. Violence, like drunkenness, was becoming disreputable. The last few years, unfortunately, have seen a reversal of "progress" in this respect at least, and gentleness has ceased to be admired: communism, and its natural—its inevitable—anti-body, fascism, have taken charge of the minds of a large section of human society—religious and political toleration is on the wane.

It needs no historian to recall how learning, scholarship and art, on the one hand, and natural philosophy and technology, on the other, have from early days been largely international in their

scope. In the western world, torn often with cruel and useless struggles, these were the only common interests of mankind. It is pleasant to remember how philosophers and scholars could, usually without hindrance, even in time of war, continue uninterrupted their intercourse with other countries. A document now more than 700 years old records the presence at Padua of French, English, Norman, Provençal, Spanish and Catalan students. Later at Padua 22 "nations" were represented, 12 from Italy itself, 10 from beyond the Alps. In the fifteenth century there were about 100 French students there, nearly as many English and Scottish, over 300 German. In spite of all difficulties of transport and communication there was a very real international sense in the humane pursuit of learning. Had learning and science had no other gifts at all to offer to mankind, their habit of transcending language, nationality and prejudice would have made them, more perhaps than anything else, worth while.

Religion should have played, and sometimes actually did play, this part; too often, however, it was associated with the bitterest struggles of all. The persecutions of the Huguenots in France continued for nearly three hundred years; the last serious persecution was as late as 1815. The Edict of Nantes, which has been described as "one of the most flagrant political blunders in the history of France," caused, it is estimated, in a few years, the loss of nearly half a million citizens—citizens who, when assured of liberty of conscience, always showed themselves loyal and desirable subjects. Many of these emigrated to England and Prussia, where they contributed greatly to the commerce and culture of their adopted countries. The present persecution and emigration of German scientists are closely parallel to those of the French Huguenots.

The growing interest in science led in the seventeenth century to the foundation of societies and academies; those of London, Florence, Vienna and Paris were started about the middle of that century, that of Berlin in 1700. These academies, by their friendly relations with foreign scientists—the Royal Society published a large part of the writings of Leeuwenhoek and also of Malpighi—did much to uphold the superiority of science to national frontiers. One effect of this, however, was an increased use of the native tongue in scientific communications, instead of Latin, and this proved an obstacle to scientific intercourse. At the present time, in some countries, national pride rather than ignorance of a foreign tongue insists on publication in languages unknown to the majority of scientific workers. The spread of nationalism acted in the same direction. France, for example, in recent years has been singularly unwilling, perhaps unable to realize the need, to send her young men to study in foreign countries—with the result that in most subjects her science has lagged behind that of England, Germany and America, and even of some of the smaller countries of Northern Europe.

Increasing ease of transport to some degree compensated the abandonment of Latin as a common language. As communication, however, became easier and education more wide-spread, one might have expected that the common interests of mankind would have been more evident than they were. It almost seems to be true that the gods, when they offer one gift, send with it some counter gift to plague mankind. Nationalism in its present embittered form, spreading like a cancer over the earth, is one consequence of the very forces which one might have hoped would have made people realize their common humanity. A tinge of education, instead of making people more reasonable, seems to render them an easier prey of unscrupulous

propaganda, more subject to the hysteria of mass suggestion. If one's only form of literature is the cheaper press, with its appeal to emotion rather than intelligence, it is little wonder that one should be led, contrary to reason, into emotional absurdities. It would not be difficult for a cynical observer, experienced in neurology, to find exact clinical parallels to those hysterical outbursts of nationalism which make all attempts at a reasonable solution of world problems so difficult. These disorders of mind and emotion have spread themselves by the imperfections of the very factors which—one hoped—would render them less likely. Never before were wars on so national a scale: never national hatred so widespread, national illusions so obstinate. I was at Stockholm once when a famous Irish poet, who had accepted all manner of kindness in England, caused great annoyance among his hosts there by his continual public references to England as "the enemy." Anti-semitism in France, culminating in the Dreyfus case, was a disgrace of which Frenchmen do not care to speak—it ruined the French Church, it nearly ruined France. Yet it was nothing to the excesses of anti-semitism in Germany to-day.

If there be one single idea which, by common consent and with common applause, represents the contribution of England to the common welfare, that idea is freedom—freedom of action, freedom of belief, freedom of thought and speech. The American Commonwealth was founded by English people on the same idea. Often, it is true, Englishmen have sinned, sometimes grievously, in this respect, but a jealous tradition, on the one hand, and bitter experience, on the other, have kept their country on the whole the freest in the world.

Now freedom, like health, may be a citizen's birthright, but it needs safeguarding. It is easy to allow bad habits to creep in unobserved, to tolerate a weakness or disease in its earlier stages until it gains too firm a hold. Freedom, like physical fitness, requires a constant effort. Those who will not fight for freedom do not deserve to be free. We can not trust to the victories of our forefathers: we must be ready—as Huxley was ready—to take part in the conflict ourselves.

When I accepted the invitation last January to give this lecture I had intended to speak of science—as to some extent I have spoken—as a common link between the different races of men, as a means of promoting international understanding. To thinking people the progress of knowledge, the advance of medicine, the improvement of health and happiness which can be—should be—the result of scientific and technical achievement, are among the major interests of mankind. It seemed that nations and governments were certain, gradually, to realize this, and so would encourage cooperation, at least in intellectual things. Private agencies have contributed very generously in recent times to this end. University College, London, for example, has been greatly aided by gifts from the Rockefeller Foundation to medical science and to biology, and to me alone in the last ten years that organization has sent about twenty fellows of ten different nations to work there. I know how much friendliness has been produced by the intercourse so made possible. A few years after the war two other such fellows—a Belgian who had served in the Belgian armies in the field, and a German who had served in a German submarine—worked side by side with Starling there: without any disastrous consequences! All over the world, not only in education and in fellowships, but in field investigations of such diseases as yellow fever and malaria, the Rockefeller Foundation has been contributing (to use the terms of its charter) to the welfare of mankind throughout the

world. Their work is done, not in any religious fervor, not with flowery language, but as a matter of ordinary business and common sense—not meddling, as Hooke wrote, with divinity, morals, politics or rhetoric. The voluntary migration of hundreds of young scientists under the auspices of the Rockefeller Foundation recalls the movements of earlier times among the universities of Europe. The Rhodes scholarships, the Commonwealth Fund fellowships, the Guggenheim fellowships, serve similar ends. All these are bound to affect—I know that they have greatly affected—the outlook of the younger generation of scientific workers; these at least, however good citizens they may be of their own countries, will never be bound by a provincial nationalism.

The history of science, since the war, has been largely of an effort to break down national barriers of mistrust or lack of understanding. In 1923, before an International Congress of Physiology in Edinburgh, various representative British physiologists were asked whether they approved—the French physiologists did not—of an invitation being issued to scientists in the late enemy countries. The general reply was that if the Germans were not to be invited they themselves did not propose to attend. The Germans came, and friendly relations were opened up again between physiologists: earlier than between almost any other groups on the two sides. The political difficulties in other departments of knowledge have varied. Where, as in chemistry, competitive industrial or military application interfered, progress was relatively slow: in astronomy and physics it was rapid. This, however, is not the sole criterion, for physiology also deals with rather practical affairs: in physiology there happens to be a very friendly international spirit, bred partly by the congresses which Michael Foster founded in 1889. It is quite certain in any case that science can not progress properly except by the fullest internationalism. Accepting freedom of thought and research as the first postulate, the second is that knowledge, however and wherever won, should be freely available for the use of all. Up to the beginning of the present year one lived in hopes that reason was being restored.

Disillusion, however, has been brought to many by the events of the last nine months. No country has excelled Germany in its contribution to science in the last hundred years, no universities were traditionally freer and more liberal than the German. One felt that the intellectual cooperation of Germany was a necessity in setting science on an international basis. I had intended, in this lecture, to urge an ever closer cooperation. Germany, however, has lately rendered such intellectual cooperation impossible by offending the first and most fundamental rule, that providing freedom of thought and research. Such disasters have happened before in history, but one felt that the world had outgrown them. It seemed impossible, in a great and highly civilized country, that reasons of race, creed or opinion, any more than the color of a man's hair, could lead to the drastic elimination of a large number of the most eminent scientists and scholars, many of them men of the highest standing, good citizens, good human beings. This, nevertheless, has happened: the rest of the world of learning is gasping and wondering what to do about it. Freedom itself is again at stake.

The facts are not in dispute. I speak with some knowledge, having a personal acquaintance with, and having recently seen, many of the victims of the Aryan myth. Apart from thousands of professional men, lawyers, doctors, teachers, who have been prevented from following their profession; apart from tens of thousands of tradesmen and workers whose means of livelihood have been re-

moved, apart from 100,000 in concentration camps, often for no cause beyond independence of thought or speech, something over 1,000 scholars and scientists have been dismissed, among them some of the most eminent in Germany. These have committed no fault. Many of them are patriotic citizens who fought in the German armies in the war. One of them I know escaped from the French and went on fighting. One of them had a great-grandfather who fought in Blücher's army in the Waterloo campaign. Many of them are of families which have been in Germany for centuries: not all of them are even partly Jews. It is difficult to believe in progress, at least in decency and common sense, when this can happen almost in a night in a previously civilized state.

What can be done about it? The immediate answer is, of course, that suffering must be relieved and opportunities given for the continuance of their work to those who have been persecuted and deprived. A more important matter, however, is this—we must ensure that the same folly, the same fury, does not occur elsewhere. We can not take the freedom, so slowly and hardly won, as a birthright: we must see to it that neither race, nor opinion, nor religious belief, nor the advocacy of theories unpopular perhaps at the moment shall cause disinterested able men to be deprived of the means of carrying on their work, even in some cases of their means of living. Mankind must not allow its cynics to reflect, with Richet, that its generic name, *homo sapiens*, had better have been *homo stultissimus*.

It is a gloomy outlook, and I can see little hope at present except by the strenuous cooperation of intelligent people of good-will in the various countries. I trust I am neither highbrow nor pessimist, and I know that I have great confidence in the moral judgments of ordinary folk. I have, however, little faith in their intelligence. Two friends of mine, a gardener and a cook, most excellent people, plain, simple, kindly, honest, can be deceived so easily that one need pay no attention at all to their opinions. With all my regard for them as human beings I can have no faith in the dictatorship of any proletariat of which they are typical. Equally difficult, however, I find it to believe in the dictatorship either of undergraduates or of glorified Boy Scouts (much as I love and admire these in their proper place). Of one thing, however, one can be certain, that in a civilization tottering unsteadily on a foundation of applied science, it is necessary that people scientifically trained should take some part in affairs. That need not imply that Cabinet Ministers should be fellows of the Royal Society, but rather that all educated men should have some appreciation, by direct contact, with the methods and ideas of science. It is perilous to disregard the scientific basis of modern civilization or its dependence on international cooperation. Science and learning—for all I said earlier in my lecture of their independence—must realize that they exist, not only for their own sake, not only for what they can do for the material welfare of mankind, but perhaps chiefly for the fact that they alone seem to be truly international, to be capable of transcending national follies and absurdities.

I do not suppose we can do very much, and I can imagine that *homo sapiens* may ultimately destroy by his irreconcilable folly all he has built up. His idea of progress, powerful as it is at the moment, may be nothing but an extrapolation from a short portion of a curve. The pterodactyl's achievements in aviation did not prevent him from dying out: he had some fundamental unfitness—may it have been an emotional one?—which for all his progress put an end to his career upon earth. Mankind's amazing intellectual achievement in under-

standing and controlling the forces of nature may be neutralized by the domination of his intellect by his passions, by his emotional inability to realize, what must be obvious to his intellect alone, the demands of a common humanity. The complete inhibition of his higher intellectual centers by storms of emotion from below, associated with delusions of grandeur or persecution, if persisted in for generations, may render him, for all his progress, in fact because of it, as extinct as the pterodactyl.

The outlook, however, is not everywhere so bad and I venture still to think of science and learning, particularly science, which in its experimental method has an absolute means of deciding between opinions, as being the strongest links between the intelligent people of the world. Not many Englishmen, unfortunately, know much about the United States of America. People—otherwise intelligent—who would regard almost as illiterate one who had no personal knowledge of France, Italy, Switzerland or Germany, appear to be proud of their freedom from the contaminating influence of a visit to the United States. They speak as though gangsters, bootleggers, fundamentalists, kidnappers, and the uneducated, unabsorbed European masses of the great cities, were part of intelligent America. Fortunately, scientific people know otherwise: they have good reason to know that laborious scientific advances, on the one hand, or brilliant discoveries, on the other, are just as likely to be achieved there as elsewhere: and they have that close personal contact with the unassuming friendly people who make these contributions to knowledge, which ensures that the scientific community at least would regard as utterly hateful any serious difference between their countries. This friendly rivalry between Britain and the United States, this sense of cooperation, is a stronger link than many may imagine. We scientific people are often poor, and generally without much honor or position: it is bad perhaps for the State but good for ourselves that this should be so for social importance and intelligent honesty are not easy bedfellows; but in the end we exercise more influence than we know—for our fundamental faith is cooperation in the pursuit of an end outside and greater than ourselves.

Huxley, whom we honor to-day, had three sides to his life and character. Firstly, the scientific side, in which he showed almost unexampled precocity. With little aid, by the time he was 25, he had placed himself in the front rank of scientific investigators. Secondly, the side of public service: from the age of 37 years onwards he served on no less than ten Royal Commissions: he was secretary and later president of the Royal Society: he was a member of the London School Board: he occupied many public positions. Thirdly, the crusading side, by virtue of which he engaged for many years, against all comers, in the defense of scientific method and of freedom of thought and research. Great as were his contributions to pure science and to the state in his first and second faculties, it is for his services to freedom of thought that he will be remembered best. In a day when academic freedom is being challenged once again in many parts of the world, when honest opinion is being stifled by force, when advertisement and propaganda offer prizes to those who will deny their scientific consciences, when intellectual leaders are being persecuted by physical, not merely by intellectual, violence, it is good that we should remember and honor one whose valor in controversy made his country, for half a century at least, safe for honestly held opinion.

We need not recount his controversies: he defended the scientific method against witless prejudice and entrenched author-

ity. It is sufficient to remember him as a fighter in a good cause and to reflect that no good cause is permanently won. It is very unlikely that we shall have further struggles between evolution and the churches, but there are plenty of forces at work in the world to-day to hinder research, to destroy free thought, to strike at the root of all opinion not congenial to authority. At the moment in England we are free. We rejoice in our freedom. We can not imagine it otherwise, in spite of all our young communists and fascists. A year ago Germany was free, and its intellectual life, in its universities and its academies, was still the admiration of the world. Neither Russia nor Italy to-day can claim—their rulers indeed would probably disclaim—that honesty and intelligence are safeguards for unpopular opinion. Who knows where next the epidemic of mass-insanity may appear? A little slackness, a little lack of watchfulness indeed, and our freedom here or in North America, in France or in the countries of northern Europe may disappear in a fortnight. Let us not deceive ourselves. Many of those who now deplore most bitterly the events in Germany, the 100,000 in the concentration camps, the persecution of Jews, the blind acceptance of authority, not so long ago were maintaining that in making war at least the Germans were not much worse than ourselves. I believe they were wrong then, as I hope and believe we shall avoid the epidemic now; but we shall avoid it, not by denying the existence of evident facts, not by resting on the victories of our fathers, but by watchfulness and readiness to make sacrifices, if needs be, in the cause of intellectual freedom.

SOCIAL STRATIFICATION IN A SMALL COMMUNITY[1]

By Dr. EARL H. BELL
UNIVERSITY OF NEBRASKA

EVEN though in America, especially in the democratic Middle West, we stoutly deny the presence of social classes, they do actually exist there. This universal trait probably develops from man's desire to classify or pigeonhole individuals.

In order to study social stratification in its simplest form, I chose a small Iowa community, which we shall call Shellstone. This community is homogenous in religion, race and nationality, hence these elements will not complicate the process of social grading. There are no factories, mines or other economic agencies which bring about the obvious social cleavage between labor and capital. In other words, Shellstone is a simple, agricultural community with a small trading center.

At first sight there does not appear to be a social stratification among the people. When informants are directly approached they inevitably reply, "There are no classes in Shellstone." The organized social activities cut across all class lines. In the cities one finds different classes attending different churches. Formerly this was partially true in Shellstone, where the old aristocracy largely belong to the Baptist church, and were further set off from the multitude by dress, economic status and refinement. During the course of the twentieth century the social structure of Shellstone has been leveled downward and class lines obscured.

Shellstone likes to pigeonhole individuals, however, and from this tendency develops a loose class system. Social position is largely determined by the function which one fulfils in the economic process, and the subjective evaluation placed upon that function by the community.

But the economic position of the individual is not the only factor in his classification. It is modified by the concept of permanency of occupation and stability of character. The individual who frequently changes occupations or employers is grouped with the lower classes, regardless of his occupation at the time being. Other results of this modifying element will be cited in the section on the social classes.

In describing the classes in Shellstone one must constantly guard against the erroneous idea that the individual's personality is overshadowed by the class label. The classes described are but a rough description or classification of groups of individuals. Each of these classes have nearly as many subclasses as there are individuals. In a well-developed class or caste system an individual is first a member of a class, and then, possibly, an individual. In Shellstone, one is first an individual, and then, because of his personality, a member of a class. As a result of this personal evaluation, even with so functional a basis of classification as has been given here, there are individuals who do not fit into the classification or who do not move in the class in which we would ordinarily consider them as belonging.

In Shellstone, the banker stands at the top of the economic and social hierarchy. Economically he is the lord of the community. He knows every one by name and financial standing. In time of

[1] The data for this are taken from "An Ethnological Study of a Small Middle West Community," an unpublished manuscript.

financial stress or crisis he is appealed to for aid. The farmers ask his advice about renting a different farm, holding or selling their hogs, buying more land or making improvements on their farms. The merchants and townspeople seek his advice concerning new ventures and are backed by him financially. In case of disputes, legal or personal, he is usually appealed to and his decision is accepted by both parties. In questions involving points of law, his advice is sought. If a land deal is being put through, it is usually closed in the bank in the presence of the banker, the latter drawing up the agreement. If an out-of-town man owes some one some money, the banker writes him a letter which usually collects.

All this service is given for the asking. The bank receives no revenue from personal service. Even bank drafts cost nothing in Shellstone. This free service and advice is undoubtedly the explanation for the fact that while Shellstone has dwindled in significance as a trade and social center the banking institution enjoys as much prestige as ever before. Such human understanding and service is the secret of the popularity of benevolent despots. The authority of Shellstone's despot remains almost unchallenged by rivals or the people themselves.

The prestige of the banking families does not rest alone on their occupation. Their families were among the oldest settlers in the town and at once took an active part in the economic development of the town by operating one of the first stores. Both generations have proven themselves to be stable, balanced and dependable citizens. Their position was challenged unsuccessfully when a group of disgruntled citizens organized "The Farmers' State Bank." A very able man was put in charge, but he never gained the prestige granted to the other group. The new state bank closed its doors in 1925, and the private bank once more enjoys the patronage and prestige of the entire community. The failure of the state bank has served to augment the respect and confidence of the people for the old firm, which continues business unhampered by either state or national control.

The business associates of the banker enjoy a prestige next to that of Barter, the president, whether they may be working in the bank as cashier, assistant cashier, bookkeeper or janitor. Incidentally, they are not relatives of the banker, but young men who have been reared in the community and employed in the bank after graduation from high school. They rank high in the functional classification of Shellstone. The position not only brings them in close contact with the real power in the community, but it is a symbol of the recognition of merit. To answer, "He works in the bank," is the equivalent of saying, "He is a good boy; he is honest; he works hard; he is the most intelligent young man in his age group and he is so good that his talents have been recognized by Barter."

Next in the hierarchy are what Shellstone calls "business men." This includes all men who own or operate some kind of a business establishment, regardless of whether he sells material commodities or his own skilled labor. The important item is to have a regular place of business. The blacksmith and barber are considered as much business men as are the merchants. In this class of business men is included the owners and operators of the following businesses:

1 Produce house
1 Mill
1 Post-office
1 Shoe store
1 Barber shop
3 Grocery stores
1 Cafe
1 Furniture and undertaking
1 Blacksmith and implement shop
1 Photo gallery
1 Electric shop
1 Harness and shoe store
2 Hardware stores
1 Dry goods store
1 Newspaper office
2 Garages
1 Gas station

The above group includes thirty-six households. In the days before the trade decline it would probably have included as many more, for most clerks were considered to be in the business group, due to the relative permanency of their connection with the business institution. Shellstone places service and permanency of occupation on a par with business ownership. As a rule, the employee who works in one store for a long period of time enjoys the same social position and respect as his employer, while the individual, whether entrepeneur or employee, who changes business or occupation frequently is denied the respect and prestige granted the former.

The above list of the business class does not include the operators or owners of the following businesses:

East Side grocery	Grocery and dry goods store
Meat market	One produce house
Drug store	
Garden café	

All except the last have been omitted because they are comparative newcomers. In Shellstone, social recognition as a part of the community is not gained through the purchase of a business, but must be earned through a rather prolonged residence in the community. The above-mentioned people are, as yet, considered outsiders.

The operator of the produce house does not enjoy recognition as a member of the business class because, although he has been reared in Shellstone, he has changed occupations frequently, and for the greater part of his life was among the casual laborers with whom he is still classed.

The doctor and dentist are included in the business group. The former has been in Shellstone for nearly twenty years, but it is only recently that he has been admitted to the business group. The dentist was reared in the community and has practised dentistry here for thirty years. The agent for one of the railroads at Shellstone for nearly fifty years was classified with the business men.

The next class is landowners, including either active or retired farmers. Like the business men, they are subject to the same general rules of permanency and stability. This group is very close to the business group in prestige. In fact, the retired farmers and the old members of the business group freely mingle together socially. Formerly the partial isolation of the farmer kept the groups from becoming intimate, but since this barrier has been broken down many members of the two groups associate at the intimate level of social participation.

The farm renters, as a group, rank somewhat below the landowners, although here again the factor of permanency and ability complicates the picture. The individual who lives on the same rented farm for many years and is a successful farmer enjoys the same social recognition as the landowner. On the other hand, the poor farmer who moves from one farm to another at frequent intervals ranks with the occasional or casual laborer whom the writer shall next consider.

In any civilized community of people, most individuals need, from time to time, additional help in planting the garden, raking the yard, beating rugs, washing windows and so forth. On the farm there are times of increased activity arising from the necessity for the completion of certain work, such as planting and harvesting at a fairly definite time. During these periods, the farmers hire extra help, usually by the day. In response to this need of the community has arisen one of the most distinct classes in the social and economic structure of Shellstone. I shall call this group the occasional laborers. They are the odd job men, "Jacks of all trades and master of none." Economically they are as indispensable as any other group, but socially they do not mingle

with the other classes. As has been pointed out before, the people of Shellstone highly value permanency of employment, stability and industry. The occasional laborers lack this virtuous trinity. The very nature of their economic instability probably tends to develop inconstancy of character, or what the community designates as "laziness." The cause and effect relationship of these traits of character is believed by the virtuous to be the opposite of what has been suggested above, that is, laziness and questionable character are inborn traits which determine one's choice in the economic process. The validity of this theory is of little importance. As long as the people believe it is true, they react to the occasional worker and his family "as if" it were true.

Among the occasional laborers are a number of individuals inclined toward stealing. This is not a new group, but has been in existence since the beginning of the town. They represent the very bottom of the occasional laboring class. They work the least, live in the poorest houses, have the least amount of money and the most children, are shiftless and often dependent upon the community for support. Their thefts are usually articles of little value, such as tools, garden truck, automobile tires and accessories. Formerly, a few chickens were stolen, but due to the increased opposition of the community to chicken thieves, most of them do not take that risk.

The community knows these petty thieves, but takes no action against them as an organized community. The individuals attempt to guard their property by means of padlocks and personal vigilance. Occasionally an item of warning and bluff appears in *The News* similar to the following:

> Those chaps who are stealing Elder Brasted's wood at night had better look out. There are two revolvers at his house loaded to the brim that will explode some night and blow them where the woodbine twineth.

If one of these individuals is caught in the act of thieving, he hurries home and the owner of the property is satisfied that he has been able to retain his goods.

The bankers, and their associates, the business class and successful farmers, the poorer farmers, mostly farm tenants, and the occasional laborers are the social classes based upon the economic function plus the stability and permanency of the individuals. The lines of demarcation are vague and elusive. The upper and lower limits of the classes shade into each other. They are not institutionalized and the populace do not recognize the classes as such. Neither inheritance nor wealth are important items in determining the class to which one belongs.

The classes include only adults. Children are free from class distinction. The children of the business men, occasional laborers, farmers and bankers, play together on equal terms except when the undesirable traits of the parent are actually present in the children. Then those naughty children are tabooed except to children whose parents do not object to such behavior.

Shellstone cherishes the American myth of equality of opportunity for all and does all within her power to make it a reality. The boy or girl of worthless parents is aided and encouraged to make good. Shellstone has few opportunities to offer them as adults, but every individual will aid them during their youth in getting an education. All a young person needs to do to receive such aid and encouragement from the community is to work hard, start a savings account and be dependable. Several boys of this type have made good out in the outer world, and they are the pride of the community.

Another group of individuals, mostly unmarried men, must be described. This group is outside of the economic, functional classification. For want of a bet-

ter name, they shall be referred to as "men about town." Not even in times of labor shortage do they work. Their sustenance is from a source other than their labor, usually a small inheritance. They are honest and upright citizens, who take a far greater interest in local and national politics and problems than do their more industrious friends. As individuals (no one would think of them as a group), they attach themselves to various business houses or institutions. One of them "hangs around" one of the hardware stores, where, upon occasion, he may help load a stove into the truck. Such services are not given for pay, but in the same spirit that a farmer would "lend a hand" if he were present at such a time of need. He is also a sort of henchman of the business. If something new comes in, Shady Mack advertises it as much as the newspaper and brings his friends in to look at it, while he explains its intricacies and good points. Of course he never sells anything. If the competing hardware merchant has a different brand of some commodity, Shady is ready and willing to explain the superiority of the brand handled by the store at which he "hangs out" and the trouble given by the competitor's brand. Such a publicity man is of considerable value to a merchant.

Another of the men about town is a college graduate of about forty-five years of age. His work is caring for and representing the Masonic Lodge, of which he is one of the leading members. Not having anything else to do, he acts as caretaker of the lodge rooms, plans and directs the activities of the lodge on the occasion of the death of one of the members, visits the sick fraternal brothers and peps up the more stolid and less enthusiastic members of the order.

These men serve a public function. They have both the time and inclination to read a great deal, and are rightly considered the best generally read men in the community. Politically they serve as relay stations for the Republican propaganda. They are also informants as to the proper treatment of all plant and animal diseases, the proper time to plant and harvest the various crops, and the means and ways of destroying obnoxious weeds. Their knowledge is an amusing combination of science, magic and superstition. A detailed study of their beliefs would reveal both the progress of science and the tenacity of superstition among the ordinary populace of the American Middle West.

This group is also the exchange for news and gossip. Through them the news from one end of the community reaches the opposite end. They know all the farmers who come to town and get the news and crop reports concerning that portion of the community from which they come. From them the farmers learn the crop conditions and events of the entire area of the community.

All these functions are carried on in an informal, friendly and gossipy manner. The high regard which they enjoy, in spite of the fact that "they toil not, neither do they spin," from a community in which industry is considered one of the cardinal virtues is perhaps an unconscious recognition of their service in the social process.

The question arises as to why the occasional laborers, who spend much of their time in the same way as the "men about town," do not enjoy an equal prestige. At first thought one might believe the discrepancy to be due the wealth of these men. Such can not be the solution, for, excepting one case, the "independent means" is an extremely meager one, leaving, after taxes have been deducted, probably four hundred, certainly not over five hundred dollars per annum for living expenses.

The families from which they come were of only average standing and in one case unknown to the villagers. Shellstone does not as a rule grant recog-

nition of an individual because of the worth of his family. Both salvation and social standing is believed to be an individual matter. From the standpoint of morality and honesty, the men about town are not better than many of the occasional laborers whom they outrank.

They do differ from the occasional laborer, however, in permanency and predictability. The natives of Shellstone like to know not only what a man is doing to-day, but what he will be doing to-morrow, next week and next year, and where he will be doing it. The occasional laborer's activity and whereabouts can not be so predicted. But barring death or accident, even the child playing in the street can tell you what any one of the men about town are doing ["nothing"] and where he is doing it.

The married women of the community enjoy the social standing earned by their husband's function in the economic process. Most of the girls who remain in the community marry shortly after graduation from high school. During the period between graduation and marriage the girls are more or less outside of the social classification, but those who "get out and work" are more highly regarded than those who remain at home.

After graduation from school the boys who remain in the community begin to win their position in the social structure of the community. They are closely watched at this period. The boys who work away from home, like the girls, enjoy more prestige than those who remain with their parents. And those who secure positions away from the community outrank any who remain at home.

The local teachers and ministers are individuals who reside in the community but are not of it. They are considered outsiders and treated as such. The teachers are forced by their contracts to participate in the religious activities, and they must help the children prepare entertainments for the amusement of the community. Their contract also requires them to remain in the community a certain proportion of the week-ends. But those periods are indeed dreary times for the teachers. They are rarely invited into any homes in the community. And they must clique together for comradeship. Their every movement is watched by the people, who are ever ready to criticize their conduct. Their tenure of office is short, for, regardless of the quality of their work, the people desire changes.

The position of the minister's families is similar to that of the teachers. The men of the community do not care for the comradeship of preachers, whom they look upon as effeminate creatures who call upon the women and attend the Ladies' Aid. The conduct of the ministers and their families is subject to the same strict observation and sharp criticism as that of the teachers. Their tenure is likewise limited. The Methodist ministers are, of course, subject to the call of the Conference, which apparently recognizes the desire of the small community for frequent pastoral changes. The Baptist ministers frequently make the error of remaining too long and depart ignominiously as a result of their folly, leaving each time in their wake a church weakened and split from internal dissension.

Shellstone is a closed community and mainly self-perpetuating. It is the source of an overflow into the cities, but draws few new members from other parts, except on the fringes of the farming area. Those young people who remain within the community also marry there as a rule. Most families are distantly related, although seldom has actual intermarriage of relative occurred.

Occasionally, however, a new family moves into town. It may be that of a new depot agent, a manager of a chain store, a physician, or, now and then, some one attempting to establish a business or trade. The process by which

they are admitted to membership in the community is slow and somewhat dependent on the recognition enjoyed by his predecessor. This is evident in the reaction to the depot agents of the two railroad lines. The former agent on the Rock Island line was from Shellstone and remained in the position for fifty years, enjoying high social recognition in the community. His successor, although entirely unknown to the community, was quickly admitted to the business class. On the other hand, the Great Western line has made frequent changes about every five years, and the agents representing it have never enjoyed the full social recognition granted in two years to the last Rock Island representative.

It is practically impossible for a strange merchant to gain either social recognition or patronage. One local merchant, owning one of the most prosperous businesses in town, sold out to a stranger in 1917. His trade consisted only of a few of the curious and he was forced to give up the store. Several others followed in rapid succession, but none were able to gain a profitable trade. In 1931 the oldest firm in town, established for more than fifty years, was bought out by two very efficient business men from a distant town, where they had owned one of the most modern stores to be found in any small town. Their ability as merchants can not be questioned. Yet they have been unable to build up a trade, even when the prices on their goods are well under those of the other stores. The writer asked several people what they thought of the new store. The answers were, "I haven't been inside of it since Newcomb sold out."

A chain concern bought out a flourishing lumber business and sent manager after manager to the town in their attempt to bring the business up to normal, but without success. The people rationalized the withdrawal of their patronage on the basis that the chain concern took their money out of the community. That such was not the reason was proved by the fact that when the concern finally employed the former owner to conduct the business for them their trade immediately jumped up to what it had been formerly.

If Shellstone were isolated from the rest of the world, we would believe their attitude due to suspicion of strangers. Yet these same people who avoid local stores under new management go, on the average of once a week, to a small city, where they have many business contacts with strangers. It can not be that, although they do not fear to be among strangers, they yet fear strangers in their midst.

We shall now turn to an examination of cases in which newcomers have been admitted to the community. The most frequent source of influx has been young men who come to the community and "hire out"[2] to some local man either on a farm or in some business such as drayage. There are many cases of this kind in which the immigrant works with his employer and is sponsored by him, so to speak, and finally becomes a recognized member of the community.

One merchant, when he bought out a business, retained all the old clerks and remained in the background himself. The business continued without any dissensions, although he and his family were not admitted until several years later. Recognition as a member of the group was gained through one of the lodges to which he and his wife both belonged and which they attended regularly, although they were not cordially accepted. After more than two years one of the leading business families became friendly with them and the two families "went around together." As soon as they were thus sponsored, admittance into the community was granted.

Another important item in business success for a newcomer is patronage and

[2] This was of frequent occurrence until within the last twenty years, but is now rare.

recognition by the dominant families, who, as mentioned elsewhere, are the bankers. Newcomers who have been admitted have told the writer that without the acceptance of that group it is practically impossible to make a living from a business in the town. Another family important to the newcomers is the Wests, who are one of the most dominant families in the Methodist Church. Mrs. West is one of the few who will take it upon herself to get acquainted with new people and—still more important—if she likes them, their praises will be sounded throughout the community. Of course, if she does not like them her influence is equally strong in the other direction.

Admittance to the community through the farming group is not so difficult to gain. The very nature of farming requires an exchange of work among the men, and as the newcomer is usually a renter he is sponsored by his landlord, who is usually a retired farmer living in town.

Formerly the women of the town or neighborhood called on the newcomers at an early date after they were settled. Such a practise has for the most part been dropped. Now the newcomers must take the aggressive part. After they have met people who seem agreeable, or with whom they wish to become more friendly, they must plan an auto party or invite them over for an evening. It is only by becoming intimate with an accepted family and thus gaining a sponsor that they can hope to gain recognition. And the newcomer must play the aggressive part or remain at home friendless in a strange community. This change of folkways may be due to the increased importance of the acquaintance groups as opposed to the neighborhood group.

Formerly the agricultural area was divided into neighborhoods, that is, a small area in which the people were closely associated, socially. The most of an individual's close friends lived within this area. It was the unit of many social activities. Now the neighborhood exists as an economic unit, but not as a social unit.

In place of the neighborhood group there has developed the congeniality group. Geography no longer determines one's friends and acquaintances, but has given way to the choice of the individuals. As a result the social groups in Shellstone are of a more homogenous character now than formerly.

CONSERVATION OF GAME OR OF WILD LIFE—WHICH?

By W. L. McATEE

BUREAU OF BIOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF AGRICULTURE

To many, game *is* wild life or at least the only part of it worthy of attention. To others, game is an artificial classification for a limited number of species which are no more interesting nor more worthy of preservation than others. To the present observer and writer, endeavoring to be fair, it seems that the view of the latter group is the more nearly correct. If we tabulate the number of kinds of animals reckoned as game or non-game, we find that 88 species or 14.66 per cent. of our fresh-water fishes, 69 or 8.50 per cent. of our birds, and 82[1] or 12.24 per cent. of our mammals are currently classed as game, while no amphibians or reptiles seem to be so regarded. If we take the percentage of the total number (239) of game species among those of all (2,368) of the five groups, we find it to be just about 10 (10.09). What of the remaining 90 per cent.? That 90 per cent., from the standpoint of general wild life conservation, is certainly entitled to consideration.

Upon what basis, it is fair to inquire, does game rate the inordinate share of attention it receives? For its food value? The answer is "Assuredly not," and for several reasons. For one, every piece of game consumed costs on the average many times what an equivalent in food value could be purchased for in the market. For another, game, except to settlers or travelers in remote districts, is no longer an indispensable part of the food supply. It could not be, indeed, for our population could eat all of the game in the country, if available, in a day—almost, we were on the point of saying, at a meal. The essential basis of civilization is reproduction of food supplies, and we are so far civilized as to be cursed all the while with overproduction. Except under pioneer conditions now all but vanished, game is not necessary for food, and its pursuit therefore comes under the heading of non-essential activities.

The recreational value of the pursuit of game admittedly is large, and is the greatest public value now dependent on game. But is it indispensable? Ask the golfer, or any other out-of-doors enthusiast whose recreation does not involve the hunting and killing of wild life. The chase may be, nay is, defended on a variety of grounds, but in fairness even its strongest proponents must admit that under present conditions it falls largely in the luxury class. All this is not necessarily to decry hunting, but to lead the way to a conclusion the writer deems inevitable, namely, that hunting being a luxury, there is no validity in arguments for sweeping aside everything that interferes with it.

That such demand exists is obvious but even so some readers may wish to scan the evidence with their own eyes. It is given in the case of land game by the following quotation from a published report on a leading state game department: "The Conservation Department is entirely awake to the vital importance of unstinting warfare upon 'vermin,' if a plentiful supply of game and other useful wild life is to continue. . . . Every sportsman, every farmer,

[1] Only 18 groups or "species" of bears are counted.

and everybody else who believes in the conservation of useful birds and animals must enlist in the campaign and do his share." The same organization has the following to say regarding the enemies of game fishes: "The tremendous drain on game fish, their rapid depletion in our lakes and streams, and the urgent demand that we conserve and replenish these denizens of our waterways necessitates the most thorough elimination of all agencies which are detrimental to the welfare of game fish."

Let us consider what constitutes the groups of wild life dubbed "vermin" by those interested primarily in game. The tendency is to condemn these out-of-hand and to wage war upon them at every opportunity. But what are "vermin"? They are not animals that have no value of their own and in which no one is interested. On the contrary the largest single group of creatures that game protagonists regard as "vermin" are the fur-bearing mammals. These animals are a source of revenue to trappers, and to the fur industry in all of its branches and they are protected by law almost to as great an extent as are game animals themselves. This protection often is conveniently forgotten but there would seem no legitimate basis for prejudice against this group compared to game, as it has a value of its own and has won legal protection strictly on its merits.

Of the birds classed as "vermin" more than half of the species, including most of the fish-eating kinds condemned by anglers, are protected by federal law. This protection was not given without good reason: it was to guard the birds against extermination. Many of them were threatened by the plume trade, and some, as mergansers, are part of the class of migratory wild fowl upon which it was necessary to restrict the open season. From the standpoint of general wild life conservation, the protection of these species against extermination is a far more valuable and desirable thing than is maintenance of a killable surplus of game species.

The "vermin" species among amphibians and reptiles are more generally regarded as of little worth but some of them as the alligators and snapping turtles have commercial value. The main value of the spawn-eating and other "vermin" fishes is as a food supply for the game and commercial fishes.

The numbers of game and commercial species in the various orders of animals, compared to those regarded as "vermin" are shown in the accompanying tabulation.

Wild life group	Approximate total number of species	Game and commercial species	Per cent.	Reckoned by some as vermin	Per cent.
Fishes (fresh-water)	600	132	22.00	378	63.00
Amphibians	138	3	2.17	3	2.17
Reptiles	149	24[2]	16.10	60[2]	40.26
Birds	811	69	8.50	142[3]	17.51
Mammals	670	198[4]	29.55	189[4]	28.20
Average			15.66		30.23

[2] 5 species (including the crocodile, alligator, and snapping turtles) are the same in each group.

[3] 76 of these species are protected by federal law.

[4] 116 species (fur-bearers) are the same in each group; many of these animals are protected by state laws.

ECONOMIC CLASSIFICATION OF WILD LIFE OF THE UNITED STATES

FRESH-WATER FISHES

Species of game or commercial value: Spoonbill, 1; sturgeons, 7; herrings, 2; shads, 2; whitefishes, 21; salmons, 6; trouts, 32; graylings, 2; smelts, 3; eel, 1; buffalo-fishes, 3; redhorse, 1; carp, 1; fall fish, 1; squaw-fish, 1; catfishes, 10; pikes, 5; sunfishes, 22; crappies, 2; basses, 2; perches, 2; striped basses, 2; white perches, 2; sheepshead, 1.

Species often classed as vermin: Lampreys, 9; gars, 3; dogfish, 1; suckers, 43; minnows, 227; madtoms, 10; sticklebacks, 6; darters, 65; sculpins, 13; ling, 1.

AMPHIBIANS

Species of game or commercial value: Frogs, 3.

Species often classed as vermin: Mud-puppies, 2; hellbender, 1.

REPTILES

Species of game or commercial value: Crocodile, 1; alligator, 1; chuck-wallas, 6; snapping turtles, 3; terrapins, 2; green turtles, 2; hawk-bill turtles, 2; loggerhead turtles, 3; soft-shell turtles, 4.

Species often classed as vermin: Gila monster, 1; racers, 10; chicken-snakes, 10; water-snakes, 12; coral snakes, 2; rattlesnakes and allies, 20; (sometimes the alligator, crocodile, and snapping turtle), 5.

BIRDS[5]

Species of game value: Geese, 8; ducks, 25; grouse, 12; partridge, 1; quail, 6; pheasant, 1; turkey, 1; limpkin, 1; rails, 7; gallinules, 2; coot, 1; jacksnipe, 1; woodcock, 1; doves, 2.

Species often classed as vermin: Loons, 4; grebes, 5; pelicans, 2; cormorants, 5; water turkey, 1; herons, bitterns, etc., 12; mergansers, 3; hawks, 28; jaegers and skuas, 4; gulls, 20; terns, 14; skimmer, 1; auk, 1; murres, 2; guillemots, 2; puffins, 3; road-runner, 1; owls, 17; kingfishers, 2; jays, 6; magpies, 2; crows and ravens, 4; dipper, 1; shrikes, 2.

MAMMALS

Species of game or commercial value: Bears, 18; squirrels, 7; rabbits and hares, 19; peccary, 1; elk, 3; deer, 8; moose, 2; caribou, 13; antelope, 1; bison, 1; muskox, 1; sheep, 6; goats, 2; (116 species of fur-bearing animals which may also be reckoned here), 116.

Species often classed as vermin: Opossums, 2; raccoons, 3; civet cat, 1; martens, 7; weasels, minks, etc., 23; wolverines, 7; otters, 3; skunks, 20; badger, 1; foxes (some game), 17; wolves, and coyotes, 15; bobcats, lynxes and mountain lions, 11; sea-lions, 2; seals, 6; spermophiles, 40; chipmunks, 16; red squirrels, 3; cotton rat, 1; wood rats, 10; armadillo, 1.

In every case the number regarded by some as "vermin" is about equal to or exceeds that of game and commercial species, which brings up the question at once as to the advisability of sacrificing the former for the benefit of the latter. The general conservationist certainly will oppose the proposal and again he will have logic on his side, certainly so far as game and opposed groups are concerned, as they are on about the same footing so far as essential value to the country is concerned; under these circumstances it is natural to favor the groups in proportion to their numbers.

With respect to the "commercial" species, it must be admitted that they are not commercial in the sense that poultry and cattle are, for the market product is merely drawn from a public stock with the production of which the marketer has had little or nothing to do. In such a case, the fish supply for instance, if the public by statute protects fish-eating birds, that is merely another way of saying that the public wishes to devote to the upkeep of these birds whatever quantity of fishes is required. The harvest, like all harvests of natural products, should be from a surplus, and in the case outlined the surplus does not begin until the needs of community-protected fish-eaters are satisfied. Parenthetically it may be noted that in reality all of this is not nearly as bad as it sounds, since the prey of fish-eating species is largely derived from the non-commercial and non-game fishes, that is from groups, some of which are usually named in the "vermin" class. This follows inevitably from the general law of predation being in proportion to population—since the non-commercial and non-game fishes under nearly all circumstances far surpass in numbers the more valuable kinds.

Exceptional cases are at fish hatcheries and fish ponds where valuable species are being propagated, and due provision has been made by the federal government for control in such places of the destructive activities of birds protected

[5] Stragglers and permanently protected species have been excluded.

by national law. Similar exceptional cases involving game species are game farms and game refuges, where the primary purpose, fostered by definite efforts and expenditures, is game production.

These principles, however, cannot legitimately be extended to "vermin" control at large and it is efforts to do this that so justifiably arouse the protests of general conservationists. The country at large is not now and never will be comparable to a game farm and efforts to apply a single phase of game farming —"vermin" control, when all of the others are lacking, is indefensible and contrary to sound public policy—policy that should consider equally the interests of all classes and of all things.

Not to exceed 10 per cent. of the wild life species of the country are game and only about 15 per cent. have either game or commercial value. Many of the species of commercial value are rated as "vermin" by game breeders and together with other species put in this category by hunters and fishermen make up about 30 per cent. of the total number of our forms of wild life. The remaining "greater half" presumably are neutral from the "vermin" point of view. But what of the 30, shall they be considered fair marks for warfare in behalf of the 15? Since they include all of the valuable fur-bearers of the country as well as other species having some commercial value, many protected by law, besides numerous interesting species that for good and sufficient reason have been given strict legal protection, the answer from the legal standpoint alone is a decided negative. Campaigns against "vermin" cannot be carried on without grave risk of law violation.

Other forms of wild life often referred to as "vermin" include birds that are by no means chiefly injurious in their feeding habits, as well as reptiles and mammals that do little harm. All are interesting species, the extermination of no one of which is desirable.

Conservation of wild life is a broad term and it applies to all species. Half of our wild life should not be forgotten, nor should three-tenths be sacrificed for the benefit of one-tenth. Attempts to conserve in the wild one group at the expense of another is seldom justified. Those favoring far-reaching "vermin" control should be able to see that the general public, so far as it is interested at all, is interested in wild life in general, not especially in game, also that there is a class of the population, probably as numerous as their own, that is definitely interested in general conservation as opposed to game conservation.

To put it concretely, when anglers wish to shoot up a colony of great blue herons which they consider detrimental to their interests, they should consider the following facts. This heron is a large, ornamental and interesting bird, the mere seeing of which makes a red-letter day for a nature lover; it is a migratory species which thus shows itself to naturalists over a wide range. If destruction of the birds has the effect hoped for, it will at most mean only a few more trout to be shared among all the anglers of the region. The catching of these trout is not a necessity to the anglers, it only affords a thrill and no greater one than the nature lover experiences from observing the herons. There is no argument for sacrificing the pleasure of the general conservationist to that of the fisherman. In addition, the fact should be very seriously considered that the heron does not feed exclusively or even largely on trout. It eats insects, mice, gophers and many other creatures, and from the very nature of things catches as a rule far more coarse than game fishes, and these are

those very enemy and competitor fishes that are known to be the greatest check on stream restocking operations. At the same time these fishes in their younger stages are an important source of food for the game species. In addition to all else that has been said, anglers should remember that the number of fishes cannot be increased indefinitely. A stream or lake has only a certain fish-carrying capacity, and if an excessive number of fishes are present, they will be of smaller size.

Interrelations of forms of wild life are highly complex, and building up the sport of trout fishing is not so simple a thing as implied by the slogan "Come on, boys, let's shoot up the herons." A typical feature in such a case also is the law violation involved, as great blue herons are protected by federal law. This is merely an illustrative instance; in all others as well difficulties will be found, and similar entanglements of life relationships, like confusions of interests.

Conservation of game alone cannot be successfully achieved by hastily adopted and ill-considered methods, and conservation of wild life in general, which is the only sound public policy, should be based on the most complete obtainable knowledge, on justice, and consideration, giving due weight to the interests of all people and to the welfare of all nature.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

HOW ANIMALS SPEND THE WINTER

By AUSTIN H. CLARK
U. S. NATIONAL MUSEUM

WINTER out-of-doors, when compared with summer, seems almost a dead season. Most of the trees are leafless, and the grasses and low plants are dead, or at least seem to be. In the north the ponds and lakes and streams are blanketed with ice more or less completely, and the ground is frozen for some distance down.

Most of our familiar friends among the birds are missing, but in compensation for their loss we see, chiefly along the coast and about the open waters of the larger streams and lakes, various other kinds that are not with us in the summer. Nearly all the various sorts of field-mice have completely disappeared. The bears have vanished from the wilder woods. Squirrels are seen but rarely, and only on warm, bright and sunny days. Snakes, turtles, frogs and toads are merely memories. And there are no flies or wasps or bees or butterflies or other sorts of insects.

The world seems almost dead. And yet we know that with the advent of the warm spring days it will come to life again. So it is clear that it is not really dead, but merely sleeping; that somewhere and in some fashion most of the familiar life of summer is resting quietly, but is prepared and ready to awaken and to become active with the coming of the spring.

Some creatures are always active. For instance, all the birds are just as lively and alert in winter as they are in summer. They live the same life throughout the year. With us the crows and jays and various other kinds of common birds are just as familiar features of the winter landscape as they are of the green woods and fields of summer. But in the case of very many birds the coming of the winter reduces their food supply, or even altogether cuts it off. As an example, the disappearance of the insects cuts off the food supply of the insect-eating birds; and the freezing over of the ponds and lakes and streams prevents the ducks and geese and herons and other water- and shore-feeding birds from getting the food they need.

So in order to live during the winter months most of the northern birds are forced to leave their homes and to move southward into regions where the insect life has not been chilled into inactivity, and where the waters are still open.

Some of our birds, as the common robin, go only a short distance southward, into the southern states, where the winter is less severe than it is in their northern homes. Others, like the swallows and the warblers, go further, to Central and northern South America and the West Indies. In the West Indies in the winter, in the heat and brilliant sunlight of the Tropics and among the palms, bananas, mangoes, limes, nutmegs, bread-fruit, and many other equally unfamiliar plants, and along the white and glaring coral reefs, it is an interesting sight to see several of our familiar northern birds apparently just as happy and just as much at home as they are with us. For instance, our kingfisher is a well-known and common bird in the West Indies, and about the

bushy hillsides and the gardens of those islands our redstart is not at all uncommon. Along the mountain streams the spotted sandpiper runs about wagging his tail just as he does along the streams in Massachusetts or in Maine.

Birds are very interesting creatures. With nearly all of them sight is the most important sense. They find their food and avoid their enemies by means of their unusually keen eyes. A few, as most owls and night-flying birds in general, have wonderfully keen ears, but for the most part the eyes are the chief reliance of the birds. And so it naturally follows that the longer the day the longer the time in which any given bird can find its food and avoid its enemies. Night is a time of danger for most birds. The darkness brings many dangers. So besides the question of securing food there is for birds the problem presented by the long winter nights. Some birds, such as the golden plover and the Arctic tern, breed in the far north, at the time when the days are longest, or at least are very long, and the night is short, or there is no night at all. These birds after the breeding season journey south and, passing through the Tropics, spend the winter in the southern portion of the southern hemisphere, where it is then summer and the days are long. The Arctic tern has the longest migratory flight of any bird. In the summer it is found about the Arctic ice, while in the winter it is equally at home about the Antarctic ice, ten thousand miles away. This bird, the golden plover and some other shore birds have two summers every year. The shortest days they know are those they see when passing through the Tropics, where the days and nights are always equal.

The birds with their power of flight are able to move about over great distances and to avoid the northern winter by simply moving south. Among the mammals such extended journeys are only in rare cases possible. Some of the bats go south in winter, and in the early days the buffalo in the east withdrew in winter from the northern portion of its range into the southern states.

But most of the mammals stay more or less at home in winter, though they may wander widely in their search for food. Many of them, like the bears, the woodchucks, most of the wild mice, the common squirrels and some of the bats, when the autumn comes find a suitable place, or make one, and therein pass the winter in that long sleep called hibernation. During this period of hibernation the body temperature is lowered so that they exist with the least possible expenditure of energy.

In the same way the snakes and the box turtle find an appropriate place or burrow in the ground and sleep away the winter. The pond turtles and the frogs burrow in the mud in the shallow water along the shores of ponds or lakes or streams and spend the winter under a protective covering of ice.

The fishes for the most part stay where they are or move into deeper water. But some, like the northern trout, if they can do so, go into the salt marshes or the sea. In the far north, where the bogs and ponds freeze solid, certain of the fishes are firmly frozen in the ice where they remain immovable until the thaws of spring release them. During the short summer they are active, but for most of the year they are asleep in their solid icy prison.

The backboned animals all are large, or at least they are larger than the insects. But insects, small and delicate as they are, survive the winter quite as well as any of the backboned animals. Insects pass the winter in every conceivable way, and in every conceivable condition. Many of them, as some of our butterflies, wasps, bees, flies and others, live through the winter in the adult stage, hidden away in some snug retreat. A few warm days in winter often serve to bring them out, and they fly around

until the returning cold puts them to sleep again. Very many butterflies and moths spend the winter as chrysalids, which among the moths usually are enclosed in a silk cocoon, but which among the butterflies usually are uncovered. In most cases the caterpillars transform to chrysalids toward the end of summer or in the early autumn, and the butterflies or moths emerge in spring. One of our smaller butterflies, a very pretty one called the orange-tip, flies in March and April, lays its eggs and dies. The caterpillars that issue from the eggs feed until toward the end of May, then turn to chrysalids. These chrysalids remain inert, fastened to the trunks of trees all through the heat of summer and the following cold of winter, until in early spring the butterflies emerge. Two thirds of the entire life of this delicate little creature is spent asleep in the chrysalis.

Some other butterflies spend the winter as full-grown caterpillars hidden away in a loose cocoon. In the first warm days of spring these caterpillars transform to chrysalids from which in a few days come the butterflies. Still other butterflies live through the winter as caterpillars partly grown, which in the spring complete their growth and then transform to adults. Most of those butterflies called fritillaries, in color golden brown with silver spots on the under surface of the hinder wings, lay their eggs in summer. The little caterpillars that issue from these eggs lie quietly on the ground and will not eat until the following spring. For six or even seven months, through the heat of the late summer and the cold of winter, they are completely passive, waiting for the proper time to begin to eat. A few butterflies and many different moths spend the winter in the eggs which are laid in summer but do not hatch till spring.

In the country districts in the winter it is not unusual to see a medium-sized white butterfly in houses when it is very cold outside. This is the common cabbage butterfly which long ago was introduced from Europe and now is all too common here. The caterpillars live on cabbages and when full grown crawl away and form the chrysalids on any firm support, on fences, on the sides of barns or houses or on firewood. If logs with chrysalids on them be brought into the house the butterflies emerge, and we are treated to the unusual sight of butterflies in winter.

Life, dormant or active, is everywhere about us at all seasons of the year. Just because we do not see it in the winter does not mean it is not there.

On land the activity of most living things, such as the very numerous insects, the snails and slugs and earthworms, slows down or comes entirely to rest at a temperature of about 40°, or at the very lowest at 32°, the freezing-point of water. But in certain portions of the sea, far down beneath the surface where the sun's heat and light does not penetrate and where it is darker than the darkest night we know, there is perpetual winter with an absolutely unchanging temperature of below 30°, that is, well below the temperature at which fresh water freezes. At the temperature found at these places in the ocean's depths our lakes and ponds and rivers would be solid blocks of ice; but salt water freezes at lower temperatures than fresh, so that in these frigid depths no ice is formed.

Along the western shores of the Okhotsk and Japanese seas there is a broad band of this very cold water, and within it life is so very abundant as to challenge comparison with any other region in the world. There are various other regions where the sea bottom is just as cold as it is here, or even colder, in the Arctic and Antarctic Oceans and in the deep waters of the Norwegian Sea. In all these places, with temperatures ranging between 28.4° and 32°, animals are

especially abundant. Millions and millions of animals, living on and over large areas of sea bottom, spend their entire lives in a temperature colder than that of the cakes of ice in our refrigerators. They live in full activity and enjoyment at temperatures at which most of the life on land is dormant.

Life is full of paradoxes. On land not all the weak and feeble things are dormant in the winter. In the colder parts of the northern hemisphere there is a strange insect, a wingless kind of crane-fly or daddy-longlegs, which reverses the usual habit of insects by living in summer as a grub or larva under decaying leaves and becoming an active adult in the very coldest months of the entire year. These insects are most active in cold snowy weather from January to April, even when the temperature is below zero, running rapidly across the surface of the snow in perfectly straight lines. In April it has been noticed that if in the morning the sun shone brightly, causing a slight thaw, few of these insects would be visible. But if in the afternoon the weather changed and became colder with a flurry of snow, then large numbers would come hurrying from all directions. These insects are very sensitive to warmth, and will die in a few minutes if held in a warm hand. There is another insect belonging to an entirely different group, a wingless panorpid or scorpion-fly, looking somewhat like a small grasshopper, which has similar habits.

One of the commonest, most conspicuous and most active of the insects seen in winter is the so-called snow-flea, which is in no way related to the fleas. But this is only seen when the temperature rises above the freezing point.

Winter is an interesting season. In it the speed of life slows down—life largely comes to rest. But though it sometimes pauses, life never stops. No matter how cold and bleak it is in the woods and fields, abundant life is always there ready to resume activity with the coming of the spring.

APPLIED GEOGRAPHY

By Dr. ISAIAH BOWMAN

DIRECTOR, AMERICAN GEOGRAPHICAL SOCIETY

An American humorist once wrote a book called "Simple Jography." Whether or not modern geography is simple, we leave to the opinion of a generation that has had to learn to pronounce Wooloomoolooloo, Australia, and those strange names which the world war brought into daily use for a time. If we were deprived of Kut-al-Amara one day, we were sure to have Przemyśl or S. Giovanni di Medua in its stead. There have been so many practical applications of geography that it now stands in the company of chemistry and biology in its usefulness to man. I therefore prefer to say "applied geography," not just "geography," when talking with those practical persons who always ask, "Of what use is it?"

Since the motto of geography is "Ubique" (everywhere), we might take a look at the globe before we inquire about practical matters. Had you lived in the Middle Ages you would probably have thought, like most of your neighbors, that the earth is flat in spite of what a few scholars had been saying for 2,000 years about a round earth. It is only common sense to say that it is flat if you see but a little piece of it and do not look too closely. But it was discovered before the beginning of the Christian era that in going from Greece to Egypt, across the Mediterranean, low-

lying stars disappeared beneath the northern horizon and others appeared to rise above the southern horizon just as they ought to do if the surface of the earth is curved. A famous Greek scholar even attempted to measure the earth and made so good a job of it (three hundred years before Christ) that his result is fairly accurate and his principle is in use to-day. But he had no way of knowing if the earth were really round and whether round all the way and any way you measure it. When Columbus began his voyage he thought the earth round; he had not proved it so. It remained for Magellan to sail around the globe by instalments on two different expeditions. Even then the earth might be shaped like a spindle for all he knew. Indeed, surveys late in the seventeenth century measured arcs of meridian in France, and through error the conclusion was reached that the earth is spindle-shaped. There were not lacking explainers who said that this was due to the piling up of ice and snow in the polar regions.

The French Academy at last sent out two expeditions in 1735 to settle the question—one to a frozen lake in Lapland in a high latitude and another to a valley in Ecuador near the equator. It was these expeditions that first established the now familiar fact that the earth is flatter as we approach the poles. Sailing charts and maps to-day reflect the utmost refinements of measurement of the earth's shape and size. This knowledge and what we have learned of the motions of the earth have been applied to the arts and inventions of man in great number—the length of the meter which was designed to be one ten-millionth of the distance from equator to pole, weather forecasting which takes account of the deflection of winds in a cyclone, and even the drawing of many of our state, county and farm boundaries. Our most recent maps of the polar regions, where discovery has not yet caught up with national ambition, show the boundaries of "dependencies" following meridians into unexplored wastes, as in the Ross Dependency and the Falkland Islands Dependencies, and no doubt also in the newly announced "Australian Sector" of Antarctica. No long-range gun in the navy or the coast defense would ever hit a distant mark if account were not taken of the earth's rotation and a slight allowance made for it in calculating the direction of fire.

Many are the practical applications of geography in forecasting storms, in predicting the height of tides years in advance as calculated by a marvelously complicated tide machine, through maps and charts in daily use by tens of thousands of travelers, by the study of river and mountain boundaries in the troubled areas between nations and through the study of the rising or sinking of our uneasy earth, on whose coast-lines some of our great cities are built. Benjamin Franklin's discovery of the Gulf Stream and its effect on the routes of sailing ships from England to America is one of the great stories of applied science. The history of geographical science is a panorama of revelations about an unendingly wonderful and beautiful earth that is always as new as its newest discovery.

But these are of necessity practical days for all of us, and so I wish to speak particularly about a chapter in applied geography of importance to every man, woman and child in the United States—the use of so-called marginal land. The new administration at Washington has one overshadowing responsibility, to improve the lot of the farmer. One of our greatest difficulties is over-production. Many farmers are obliged to sell their grain crops at prices far below cost. The cause is in part a geographical question; to find a cure we are required to take account of the geography of the West particularly. There is no more inspiring process in our history than the west-

ward spread of people over our central Great Plains and to the Pacific. In the nineties the sweep of settlement was slowed down, but it was not stopped. Even to-day in parts of the High Plains of western Kansas and Nebraska and eastern Colorado and Montana, virgin grassland is being plowed for wheat. I saw the advance of the plow in Colorado and Kansas as late as the summer of 1932 and much more of it in 1930. Even the low price of wheat has not yet prevented new plowing. Droughts only temporarily halt it. The reason is that Western wheat farmers have learned a trick—how to put big machines on cheap land and by "dry-farming" raise crops that can be sold at a profit. This was true even in the discouraging markets of 1930 and 1931, when the price dropped to 60 cents a bushel. At 30 cents and less all calculations went wrong and commercial wheat-farming fell into a state of paralysis.

The wheat lands on the drier border of the plains country are among the marginal lands of agriculture and in their "continuing wise use" geography becomes an adjunct of statemanship. No government can frame a long-range policy of real value unless account be taken of the peculiar geographical qualities of the marginal lands. I have called them pioneer lands, because a pioneer is an experimenter and in the marginal lands experimentation is the first law of survival. It was by experimentation that dry-farming was learned and the edge of the wheat belt pushed forward over the High Plains of Texas and carried west of central Kansas and Nebraska several hundred miles. It opened central Washington and northern Oregon and scattered wheat fields through a half dozen Western states where only cattle ranges were known before. The use of more drought-resistant breeds of wheat helped the process vastly.

To some degree all of us everywhere are experimenters. New conditions face us daily. Galsworthy has reminded us "that the *status quo* is of all things the most liable to depart; the millennium of all things the least likely to arrive." But expermentation in the marginal lands is carried much farther than elsewhere. We, of the better-favored regions, have to adjust our minds to the fact, otherwise we miss the significance of the agricultural disease that is now epidemic in the United States, particularly in the West. At the root of that experimentation is climate. Nature takes a hand in the Western wheat-growing lands and adds to the farmer's burden, withering his crop by drought and sun or beating it down by hail. The recent Red Cross report on the drought of 1930 and 1931 describes it as a "major disaster," to which was added in parts of South Dakota and Nebraska the most destructive grasshopper plague in the history of those two states.

Our rainfall in the East may vary by several inches or by many inches from year to year, and we complain perhaps that the season has been too dry or too wet, when we are really very little inconvenienced by the change. How differently we should feel if our rainfall were 22 inches one year and but 7 the next! In such a locality there is moisture enough to permit a heavy crop one year and so little the next year as to result in complete failure. There would be no crop at all if wet and dry years came in a wholly irregular fashion, because no one would risk seed and labor. It happens, however, that both wet and dry years commonly come in groups. This means that grain and hay can be stored for use in bad years or reserves of cash built up to buy feed for live stock or to hire additional pasture. Even this would not be sufficient to enable the marginal farmer to survive if it were not for the fact that as a rule he has bought his land cheap or homesteaded it at little cost, except for the "improvements" required by law. It is also in

his favor that the taxes are relatively low because most marginal-land counties are new and thinly settled, with no large cities; and schools and other expensive machinery of civilization have not yet been developed to a state of burdensome luxury. Assessed at first as grazing land, some of the marginal wheat land is only beginning to rise in value, and the tax gatherer has not yet fully caught up with the pioneer.

The droughts and low wheat yield on dry land do not drive out the farmer, for he knows that wet years will come again and in the meantime he enjoys a relatively low tax rate. But the whole system was worked out, largely during the period just before and just after the world war, when wheat was still commanding a good price. When both wheat and cattle dropped in price, not to half but to a third or a quarter of the prices that prevailed in the dry-farming boom, the marginal farmer had to face both the exceptional risks of climate and a demoralized market. If he owed money for improvements or for additional land or for live stock and seed, he was caught between two fires. In one such county four fifths of all the families (4,500 in number) in an area as large as the state of Connecticut have appealed for Red Cross aid.

Science does not stand still in the face of such a desperate situation. It is not sufficient to feed people in distress; it is the business of government to find a cure based on sound scientific work. The Conservation Board of the U. S. Geological Survey has been at work for a number of years on the classification of the land in a broad strip east of the Rockies and running all the way from the Canadian boundary south to the panhandle of western Oklahoma. The results are shown upon a most valuable series of maps. Similar maps are now in preparation for the Great Basin covering a territory of equal extent. These maps may be called "risk maps." They show what degree of risk is involved in the use of the land as one goes from the belt of good soils and more reliable rainfall to the belt of poor soils and quite unreliable rainfall. Were these maps followed they would vastly decrease the risks and the suffering now so prevalent in the region. But the dry-land farmer is an inveterate gambler. Again and again farmers have paid their debts and saved up cash in years of rainfall and plenty in areas marked on the land-classification maps as very risky. It has not been feasible and possibly not even desirable hitherto to say to a farmer, "You shall not farm on a given territory because we believe you will fail."

The use of the marginal lands has greatly increased the wheat output of the country and helped lower the price of wheat. They now represent areas of extreme distress. What is the policy to be followed in using them more intelligently? Here science can not complete the story. To say what shall be done with the marginal lands of either Kansas or New York State is a social and political question in part. It involves the standard of living of the marginal farmer and the policy to be followed in forcibly limiting production or changing the use of the land by law. Science leaves that to policy-makers, assigning only to itself as science the duty of analyzing the situation, mapping the belts and the degrees of risk, and explaining how communities are related to the land and to each other.

This might be called the geography of internal affairs. It is a quite different type from that which deals with far-off and perhaps uninhabited lands newly discovered or of never-failing romantic interest. Who has not his land of dreams which he wishes to see some day —Patagonia, perhaps, or the South African veld or the mountains and deserts that have called men through the ages? This was the urge that sent Marco Polo across Asia to far China and

led Ibn Batuta, an Arab of Tangier, six hundred years ago, to travel 75,000 miles through the East, and that impelled Rasmussen, the Danish explorer, to travel on foot and by dog-sled about 25,000 miles in three years on a recent journey from Greenland to Siberia across northern North America. But there is also a practical aspect to geography which analyzes the soils and climates of our own countryside and the communities and neighborhoods of which we are a part. If it leaves the solution of the problem of marginal lands to other agencies of society, such as Congress, at least it constructs a scientific framework of facts and explanations. It also supplies imagination with respect to alternative possibilities, a highly important step on the way to a solution.

DANGER SIGNALS IN CANCER OF THE STOMACH

By Dr. WALTER C. ALVAREZ
MAYO CLINIC, ROCHESTER, MINNESOTA

TO-DAY cancer stands second as a cause of death. Not only we physicians but also you laymen are becoming more and more concerned over the increase in the incidence of the disease. We all must agree that the first step in fighting this or any other menace is to learn to recognize it early.

Where I work, hardly a day passes but some poor man or woman comes in with a hopelessly advanced cancer of the stomach. Our hearts are wrung by the misery of these people, and we keep asking ourselves: "Why do they wait so long to learn what is the matter; or, having learned of their danger, why are they so slow to deal competently and intelligently with the problem? When their very lives are at stake, why will they waste time with half measures? Why don't they more promptly seek out the physicians with special skill and training who are to be found in every large city of the land?"

Before attempting to answer these questions I must first admit that in many cases the poor victim is doomed some time before he knows that he is ill. Cancer cells grow so silently that often the disease is far advanced before any recognizable symptoms are produced. In such cases there is little that science can do to help.

In many other cases, however, the symptoms appear early enough, but the patient does not realize their significance; he is not worried about a little indigestion, and for a year or more he drives unconcernedly past the most ominous danger signals. Obviously, what the intelligent layman needs most is information in regard to what these signals are. He needs to know when to get worried and when to have a careful examination made of the stomach.

But before I can describe these ominous symptoms some of you already are doubtless saying: "But what is the use of bothering? If a cancer ever grows in me I will die of it no matter what is done." Unfortunately this feeling of hopelessness is wide spread, and it constitutes one of the greatest handicaps in the treatment of cancer to-day. It accounts for so many of the failures of patients to seek help when they are in the curable stage of the disease. Too often they go late, only when they are driven by pain or by the insistence of relatives.

God grant that in the next few years, with the help of the committees made up of devoted and intelligent lay people, we physicians can overcome this paralysis due to fear and hopelessness, much as, also with your help, we have overcome

similar feelings in regard to tuberculosis. To-day the word tuberculosis does not strike the same terror into the hearts of men that it did when I was a boy. We now have learned to recognize the disease promptly, and we know that, taken in the early stages, it is usually curable. Also, when I was a boy, tuberculosis was a disease to be ashamed of, to keep covered up and secret. To-day many people are ashamed to admit that a relative has cancer, but they are no longer ashamed of tuberculosis.

Soon you are all going to learn what we physicians know now, and this is that cancer in many parts of the body is curable. All that is needed is that when you fall ill you come in early enough so that the growth can be removed surgically, or destroyed by x-rays or radium, before it has grown into all-important organs, or before it has scattered all over the body. One dandelion in your lawn is easy to remove, but if you wait a few years until it has seeded itself all over the place it is hard to get out.

Actually, at the present time the average patient with cancer of the stomach, seen by a consultant or an abdominal surgeon, has had troublesome symptoms for a year or more: a most precious and unrecallable interval in which the growth has been given every chance to enlarge and spread.

We all know now that the time to cure tuberculosis is before the patient has a cough or has lost any weight. We want to put him at rest as soon as he feels weak and tired and below par. Similarly, people must learn that the time to treat cancer of the stomach is when the patient still looks healthy and perfectly well. Naturally, when cancer is beginning as a little ulcer or nodule it is too small to have any influence on the health of the patient. But it grows and grows until finally it interferes with the progress of the waves over the stomach and thus causes discomfort; or it grows into nerves and causes pain, or it blocks the outlet of the stomach and causes vomiting, or it bleeds enough to cause anemia and weakness. If only the sufferer would seek out a specially qualified physician the minute such symptoms appear he could more often be operated on with some probability of success.

Actually, the type of patient with cancer of the stomach whom consultants see to-day is often a thin, pale, weak, apathetic old man. Commonly he has a lump in the pit of his stomach, and one learns that for weeks he has been living on little but milk and soup. A year ago he may have been perfectly well, or he may have had a slight accident, or he had what was called intestinal flu, or he worried over the loss of some money or the death of a relative. These things lowered his resistance a little and made him more sensitive, and then he noticed that, for the first time in his life, his stomach didn't feel right after meals; it hurt him, and gradually he became afraid to eat. He went to the drug store and bought some tablets which some one told him were good for indigestion. For a while he was better, but then he got so bad he decided to consult the good old family doctor, who had often been a friend in need. Unfortunately cancer of the stomach was out of this doctor's line; years ago, when in college, he had been taught to recognize the disease only in its final stages, and it didn't occur to him to search for such serious trouble in a well-nourished, ruddy-looking man. Besides, he hated to put his friend to a lot of expense, so he did little more than prescribe some medicine. Later, when this didn't work, he tried another medicine and a diet.

Then the patient went to another physician, who had him x-rayed and found what he thought was a harmless ulcer of the stomach. For the next few months this was treated and every one was encouraged. But one day the patient vomited some blood, or perhaps he discovered a lump in the abdomen, or else

it gradually dawned on the family that he was wasting away, and at last he was taken to see a physician who specialized in diseases of the stomach.

After a careful examination this physician refused to hold out much hope, but advised an exploratory operation because of the bare possibility that the growth might still be removable. But it was not, so the abdomen was quickly closed, and the poor man went sadly home. He was not given x-ray treatment because, unfortunately, this is seldom of much use in cases of cancer of the stomach.

As the patient's sufferings increased, the family decided that something had to be done, and since no honest physician would promise anything, they turned to a quack, the one man who absolutely guaranteed a cure. His price of one thousand dollars, prepaid in cash, was pretty stiff, but who wants to haggle when the life of a loved one is at stake. So another mortgage was placed on the farm: the quack's medicine was tried for a few weeks, and then the inevitable end came.

In a few cases the patient who has had more or less indigestion all his life, or for several years, will develop cancer of the stomach, and he will then have what physicians call a long history. Occasionally this history suggests that the patient first suffered for a few years with an ulcer of the stomach, and then cancer came; and sometimes, on looking back, the patient will remember that at a certain time the symptoms changed in character or became decidedly more severe. But by far the commonest and most typical history of cancer of the stomach is the short one. The patient says, "Doctor, I never knew I had a stomach until this trouble began," or "All my life I could digest tacks, and now I can not stand milk."

Obviously, then, we must always be anxious whenever a person who has been perfectly well for years suddenly begins to have indigestion, or begins to fail in health, and we must be anxious even when there appears to be some slight cause for the symptoms. The danger signals are flying, and we must not be so ready to assume that the trouble is all due to nerves or worry. Young people commonly get nervous indigestion, but older men and women rarely do. It should be obvious to any one that the stomach that has been strong enough to tolerate without complaint the dietary abuse and the worries and anxieties of thirty years of adult life is not likely to be bowled over by anything short of some serious disease, such as cancer, gallstones or failure of heart or kidneys.

To sum up, then, we must worry most about the indigestion that comes out of a clear sky in persons past middle life. Cancer of the stomach is very rare before the age of thirty years, and it is commonest after the age of forty.

The question next arises: When such indigestion or failure in health comes, what is to be done? Obviously the patient must have an immediate examination, and this must be made carefully by a skilled physician. Many people keep putting off this visit to the doctor because they think only of cancer and do not know that perhaps an ulcer or a gallstone or a tired heart may be causing the symptoms. As a result, they go on suffering for months in an agony of fear, only to discover in the end, either that there was nothing to be so frightened about or else that they have thrown away their one chance of recovery.

But what is a man to do if he has always had some indigestion? How is he to protect himself from that insidious type of cancer which grows silently until long after it has scattered all over the body? There is only one way in which older people might perhaps protect themselves to some extent from this silent enemy and that is by having, at least once a year, an x-ray examination made of the whole digestive tract. The

ordinary yearly check-over of heart and lungs and kidneys is not complete enough to rule out the presence of cancer. Unfortunately, few people are now willing to go to so much bother, even when they can afford the expense, and frankly, I fear it will be a century at least before even educated and well-to-do people will face this problem squarely.

Finally, a word to those of you who have been told you have an ulcer. If your physician can assure you that this ulcer is in the duodenum, just beyond the stomach, you need not worry about it's being cancerous, because cancer of the duodenum is a very rare disease. If, however, the x-ray examination showed the ulcer to be in the stomach, if it was a large one, if you are past middle age, and especially if your symptoms have appeared only recently, the safest thing your physician can do is to assume that you have a cancerous ulcer, until this can be disproved.

Unfortunately, there are only three ways of telling a cancerous from a harmless ulcer; the first, and now most commonly used method is to let the patient drift on with medical treatment until he either gets well or dies; the second method is to excise the ulcer at operation and examine it under the microscope, and the third method is to treat the patient medically and watch with the x-ray every two weeks to see if there are signs of healing. If within a month the ulcer has not shrunk in size, or if it has enlarged, the probability is that it is cancerous, and the only safe thing the patient can do is to go to some center where he can find a surgeon skilful enough to remove the lesion together with part of the stomach.

Not all the patients so treated stay well, but enough of them do so that the gamble is worth taking. Besides, if a man has a cancer he must either take this gamble or else resign himself to the inevitable. Unfortunately, many persons at first refuse the operation: they want first to try a faith cure or some form of quackery, or they say they are resigned and hopeless, and they do not want to be bothered. I would willingly grant these people the right to make this decision if only they would abide by it; the trouble is that, later, when pain and discouragement come, many return demanding that something curative be done, and then it is too late.

To sum up again, I will say that whenever a man or woman, past middle age, begins to suffer with indigestion or symptoms that suggest that something has gone decidedly wrong with that previously satisfactory and uncomplaining piece of machinery, the body, he or she had better seek expert advice immediately, and then follow it.

Finally, may I express the hope that in what I have had to say I have not added to the painful burden of worry that many poor people carry all the time. Why should some of us worry ourselves sick over cancer or heart disease or Bright's disease, or any other disease. When our time comes we must go some way, and for all we know it may be an automobile that runs over us. I believe in being watchful, but I think we should refuse to worry or to cross our bridges until we come to them.

THE VALUE OF INSECTS TO THE CALIFORNIA INDIANS

By Professor E. O. ESSIG

DEPARTMENT OF ENTOMOLOGY, UNIVERSITY OF CALIFORNIA

INDIANS probably knew a great deal more about certain facts concerning the natural instincts and habits of insects than the white race will ever know. The aborigines of California literally lived with their tiny six-legged brothers and liked them in more ways than one. Apparently there were no feelings of rivalry on the part of the red men as is so often expressed to-day by the entomological economists who class insects as man's greatest rivals on this earth. The Indians accepted nature as it was without carrying out any ambitious schemes to replace the forests and the prairies with cultivated fields and great cities. Theirs was the lot to live with and enjoy the bountifulness and beauty of the natural paradise from which they exacted only the barest necessities of immediate life. That they had an intimate knowledge concerning the intricate life habits of insects may be inferred from the meager bits of information gathered by anthropologists in entirely different fields of science. Unfortunately the interest in Indian entomology came too late to communicate directly with these aboriginal seers of nature and what they may have gleaned by sharp-eyed and patient diligence throughout the ages has forever perished with them. The few entomological scraps which have fallen from the tables of anthropology are meager indeed, but they may serve to stimulate our imaginations of what might have been.

Insects played a conspicuous part in the legends of the California Indians.[1]

[1] E. O. Essig, "A History of Entomology," Macmillan, 1931. (Contains a chapter on Indians and insects).

The Mohave had a story concerning termites which indicates that they knew the subterranean and aerial as well as the wood-destroying habits of these rather obscure white ants. The coastal tribes of northwestern California looked upon the sand cricket[2] with almost human regard. This insect was supposed to have brought mortality to man, when he might otherwise have remained immortal. Flies are said to have first taught the savages how to mourn and cicadas how to wail.

Lice enter into a number of Indian legends. In one case the common hero coyote, after the earth emerged from the primeval flood, failing to find mankind, married a louse from whose eggs sprang many tribes.

There is a Yokut myth concerning the origin of the Pleiades. It is a little story of a flea and five girls whom the insect married and subsequently followed into the sky. "That is why there are five stars now in the Pleiades and one at the side. That one is he, the flea."

In spite of the ancestral beliefs and legends concerning lice[3] and fleas[4] the Indians were somewhat annoyed by them. I say somewhat because, as a matter of fact, the savages were apparently hardened to these pestiferous foes of mankind and actually gave them little thought or attention. However, they did try to dislodge them from the hair

[2] *Stenopelmatus longispina* Brunner, *S. fuscus* Hald. and *S. pictus* Scudd.

[3] The common head louse, *Pediculus capitis* DeGeer was undoubtedly the species.

[4] It can not be definitely established that the flea in question was the human flea, *Pulex irritans* Linn., but it was the commonest of the earliest species observed in the state.

THE SAND CRICKET, *STENOPELMATUS LONGISPINA* BRUNNER, HAS A SINGULARLY HUMAN-LIKE HEAD AND WAS THEREFORE GIVEN ALMOST HUMAN CONSIDERATION BY THE WESTERN INDIANS. (FROM "A HISTORY OF ENTOMOLOGY," MACMILLAN, 1931).

on the head. The Mohave Indians plastered their scalps with mud to kill the vermin. Among all the natives, the sweat houses and frequent plunges into the streams and lakes were also resorted to as a means of shifting the parasites. But at best only the active forms were removed and the eggs remained to furnish a new supply of tormentors in a very short time. By firing their huts countless numbers of the pests were killed, but the Indians overlooked those which were carried on their own bodies into the new abodes.

In ritualistic ceremonies and for musical instruments, many tribes in middle and northern California used the cocoons of the giant wild silkworm moths[5] for rattles. These cocoons were split open, the chrysalids removed, a few pebbles inserted, and then bound singly or in numbers to the end of a stick often further ornamented with feathers.

Few arts were to be found among our west coast aborigines. There was little or no pottery, but basket weaving attained a high state of perfection. The baskets in which they cooked were made water-tight by coating them with wax obtained from several species of coccids,[6] or scale insects closely related to the famous lac insect of India, from which commercial shellac is produced. Insect wax was also used for fastening the sinew backing of bows and even for chewing gum.

Fashionable Mohave Indian women painted their faces in butterfly patterns in red and yellow with artistic ability.

Insects appear to have been most useful to the California Indians as a source of food. When we remember that these red men ate very little real meat and that many tribes were poor hunters, it is not to be wondered that they ate everything that came their way. Professor

COCOONS OF THE WILD SILK MOTHS USED AS CEREMONIAL RATTLES AND MUSICAL INSTRUMENTS BY THE CALIFORNIA INDIANS. (AFTER A. L. KROEBER, 1925).

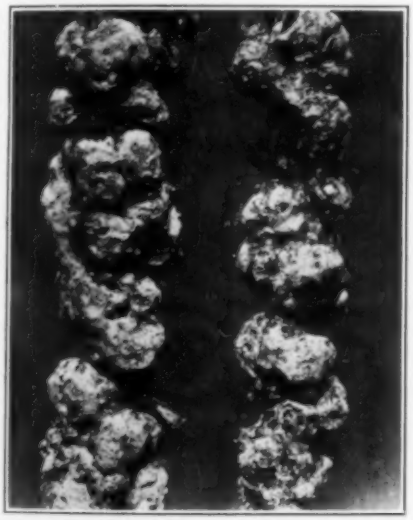
[5] *Samia euryalus* (Bdv.) and *Telea polyphemus* (Cramer).

[6] *Tachardiella larrae* Comst., *Ceroplastes irregularis* Comst., *C. quercus* Comst., and other species.

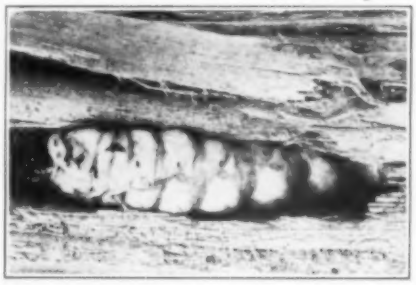
Kroeber, of the University of California, states that the "California Indians are perhaps the most omnivorous group of tribes on the continent."[7] Along the coast and streams fish, eels and shellfish were conspicuous articles of diet. But in the valleys acorns formed, by far, the most important item. Then came seeds, bulbs, roots, berries and other vegetable products. Small animals, chiefly rodents and insects, supplied most of the proteins and fats. A great number and wide variety of insects were eaten, either raw, dried, roasted or otherwise prepared.

The young fat larvae of bees, wasps, ants and wood-boring beetles were a delicious relish not often overlooked by the ever hungry boys and girls. White grubs from the sod, termites from decaying wood, crane fly larvae or leather-jackets from the wet earth and maggots from many sources were similarly sought as ready-to-eat commodities of the diet.

[7] A. L. Kroeber, "A Handbook of California Indians," Bur. Am. Ethnology, Bul. 78, 1925.



THE IRREGULAR WAX SCALE, *CEROPLASTES IRREGULARIS* COMST.
THE BODIES OF THE FEMALES ARE SURROUNDED BY A THICK COATING OF WAX WHICH MAY BE REMOVED BY BOILING WATER. THUS SOFTENED THE WAX WAS USED FOR WATERPROOFING BASKETS AND FOR MANY OTHER PURPOSES BY THE INDIANS. (FROM "A HISTORY OF ENTOMOLOGY," MACMILLAN, 1931).



THE FAT LARVA OF THE CALIFORNIA PRIONUS, *PRIONUS CALIFORNICA* MOTS. A WOOD-BORING INSECT MUCH RELISHED BY THE WESTERN INDIANS. (FROM "A HISTORY OF ENTOMOLOGY," MACMILLAN, 1931).

Aside from that obtained in the native fruits and berries, sweets were available in the form of the so-called Indian honey or honeydew, the excrement of plant lice, coccids and a few other homopterous insects. Small quantities of honey were to be found only in the nests of bumblebees and some other wild bees, since the honeybee was unknown in California until it was introduced by the American settlers only eighty years ago.

Grasshoppers[8] were universally eaten wherever available, and in the large interior valleys and along the foothills of the Sierras they often occurred in immense swarms. Then it was that the entire Indian populace turned out to gather a large part of the winter's food supply. Several methods were employed to capture the insects, but usually a fire was first built on level ground or in a pit, and when reduced to coals the drive began from afar. In an ever contracting circle the Indians beat the ground and

[8] Many species were eaten, chief of which were, *Melanoplus devastator* (Scudd.), *M. altanis* (Riley), *M. femur-rubrum* (DeGeer), *M. differentialis* (Thomas), *Œdaleonotus enigma* (Scudd.), *Camnula pellucida* (Scudd.) and *Schistocerca venusta* (Scudd.).

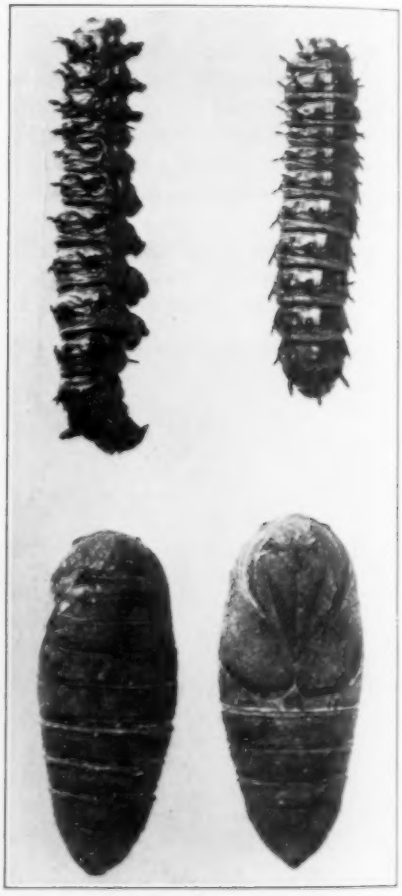
CALIFORNIA INDIANS

DRIVING GRASSHOPPERS INTO A FIERY PIT TO KILL AND ROAST THEM FOR FOOD. (AFTER J. M. HUTCHINGS, 1888).

vegetation with bushes and finally forced the bewildered grasshoppers into the masses of coals, where they were quickly roasted and subsequently stored away in bulk or impaled or strung on sticks to be eaten as we might dispose of roasted peanuts, or to be ground into a meal and mixed with pinole, or acorn meal, and boiled in baskets with hot stones. Literally tons of hoppers were thus consumed, but the annual supply never seemed to diminish for locusts were among the most serious pests which devastated the fields, orchards and gardens of the early white settlers throughout the state.

Yet another interesting insect food, still collected by the Indians in the Mono Lake region, is the pupa of a small fly[9] which breeds in unbelievable numbers in certain portions of the brackish waters of Mono Lake and other saline lakes in eastern California and western Nevada. In late summer the pupae of the fly are washed upon the shores of these lakes in great windrows. The edible part consists of a small fat body about the size of

[9] *Ephydra hians* Say.



LARVAE AND PUPAE OF THE PANDORA MOTH, *COLORADIA PANDORA* BLAKE, WERE BOTH ROASTED AND THEN EATEN BY SEVERAL TRIBES OF WESTERN INDIANS LIVING IN THE YELLOW PINE BELT OF THE SIERRA AND CASCADE MOUNTAINS. (FROM "A HISTORY OF ENTOMOLOGY," MACMILLAN, 1931).

a kernel of wheat, which is readily separated from the protective outer skin by rubbing the pupae between the hands. Nor were the squaws too particular to separate the kernels from the chaff. The material thus collected was called *kootsabe* and, in addition to becoming rancid and odorous, would keep for months and could be eaten without further preparation like raisins or popcorn. Very great quantities have been collected even to the present time.

Another astonishing food product still utilized by the western Indians is the large caterpillar of the pandora moth,[10] which feeds on the needles of the yellow pines of the Sierra and Cascade Mountains. The full-fed caterpillars are from 2 to 2½ inches long, or almost as large as your index finger. They live in the pine trees far out of reach—and only descend to the ground to enter the soil to pass into the chrysalis or pupal stage. Therefore the Indians were either compelled to await their natural descent or to resort to some means of forcing them to drop off. This they did by building a fire under the infested trees and making a smoke smudge to stupify the caterpillars which rained to the ground. These were gathered in baskets by the women, children and old men, killed and dried in a bed of hot ashes, coals and sand, and

[10] *Coloradia pandora* Blake.

INDIAN WOMAN PARCHING CATERPILLARS BEFORE A FIRE
IN THIS MANNER THE HAIRS WERE REMOVED AND THE INSECTS PREPARED FOR EATING.
(AFTER A. L. KROEBER, 1925).

A WINDROW OF THE PUPAE OF THE KOO-TSABE FLY, *EPHYDRA HIANS* SAY, WASHED UPON THE SHORE OF MONO LAKE AND UTILIZED FOR FOOD BY THE INDIANS OF THAT REGION. (AFTER ALDRICH, 1912).

stored away for future consumption. After boiling in water, without any seasoning whatever, the resulting pabulum was called *pe-ag-gie* and was fished out by the none-too-clean fingers as serving implements. Hungry whites, who tasted the food, claimed that boarding with the early Californians on the "American plan was not so good."

Other caterpillars, both hairy and smooth, were parched before an open fire by the Pomo Indians of the San Francisco Bay region and served hot or cold, or, if preferred, with less trouble, like oysters on the half-shell.

It might be thought by some of my readers that such insect food is unwholesome. While it might be admitted that most of us would not care to eat grasshoppers, maggots and caterpillars, the fact remains that they are perfectly harmless and wholesome and, if prepared in more modern ways, might even be palatable. Let me suggest that if you are ever lost and unable to secure the customary foods, you need never suffer hunger if insects are available. Even a fire would be unnecessary to prepare a meal under such circumstances.

Regardless of what we may think about the bill of fare of our California predecessors, it must be remembered that all aborigines ate insects and even to-day the abundance of grasshoppers in many old world countries may be ascertained by noting the prices in the local markets.

THE PROGRESS OF SCIENCE

EDWARD LEE THORNDIKE: PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE new president will be claimed as the honored representative of two sections of the American Association for the Advancement of Science, that of psychology and that of education. Thorndike's main fields of investigation are the psychology of learning and the measurement of mental abilities and of educational achievements.

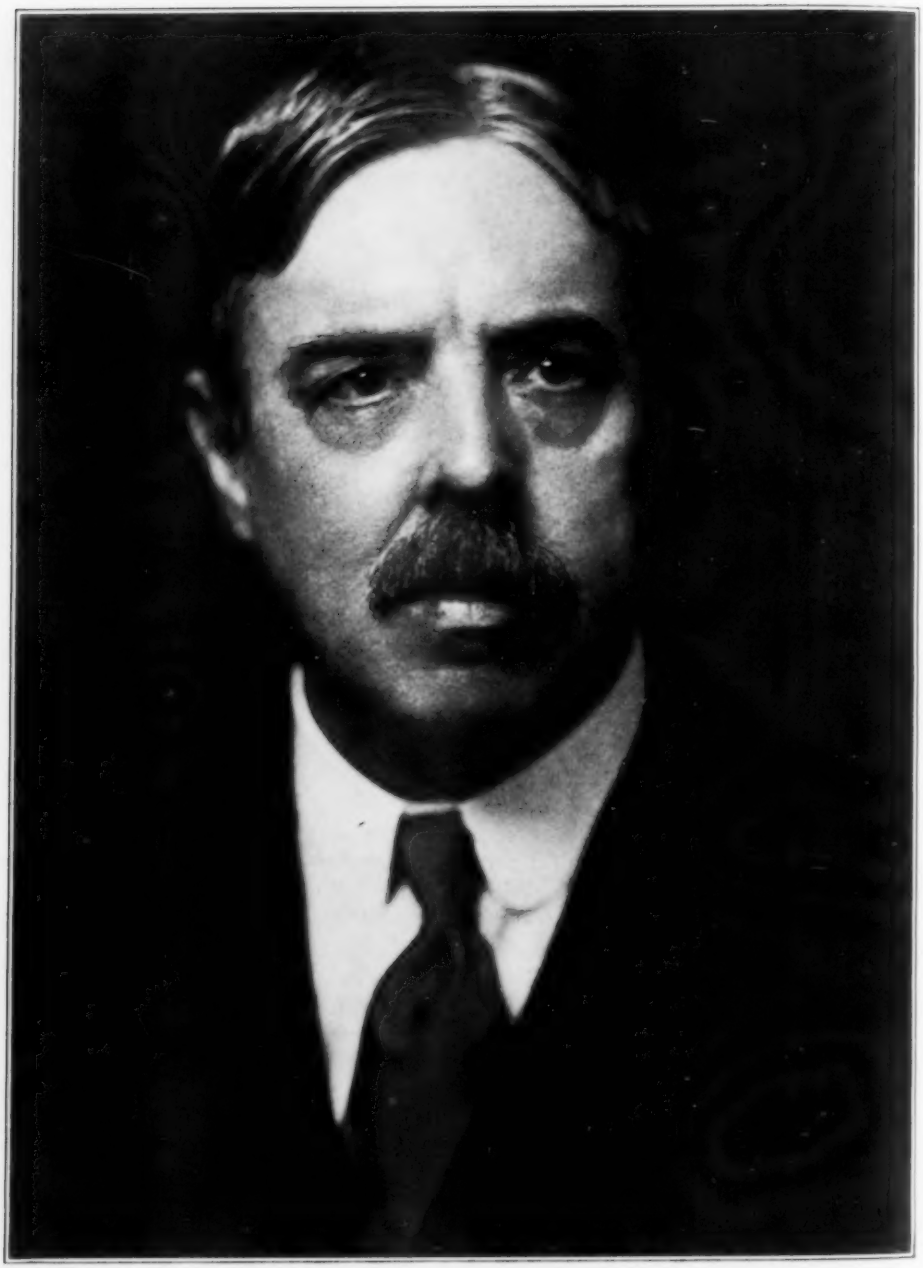
William James in 1896 recognized the promise of the young graduate student who wished to embark on quite a new line of work, the experimental study of animal learning. About a year later, two who have recently been presidents of the association, Cattell and Boas, initiated him into what was then a novelty in psychology, the statistical treatment of test results. One year more, and Dean James E. Russell detected in Thorndike the man who could be the pioneer in a scientific educational psychology, and called him to Teachers College, Columbia University, where his activities have since been centered. From the start he proved himself fully qualified, by his fearless thinking, by his untiring industry in research, by his enterprise and sound judgment alike, for the position of leadership thus intrusted to him.

There was little in existence in 1900 that could now pass muster as educational psychology or as the scientific study of education. Thorndike seized on measurement, that great reliance of the older sciences, as furnishing the key to scientific progress in education. The objection was raised, and has often been raised since, that human actions and abilities are too fluid and variable to be measured. To this his retort is that "everything that exists exists in some quantity," and that the problem is simply one of devising suitable measuring instruments. Variability must be combatted by statistical methods. So it came about that a man who was not primarily a mathematician, by any means, became the leader of educators in the use of statistics. What specially characterizes his large volume of statistical work is something that is often lacking in the mathematical statistician—a keen sense for reality and concrete probability.

Among the measuring instruments developed with rare skill by Thorndike are scales for measuring excellence of reading, English composition, handwriting and drawing and intelligence tests for various age levels, including that of college entrance. He uses these instruments not only for practical education and vocational guidance, but in research on individual differences, the influence of heredity and the growth curve of intelligence, which he finds continues rising up to the age of 18 or 20. In his "Adult Learning" he has shown that the decline in learning ability from the twenties to the forties is relatively slight, though clearly demonstrable.

Apart from these important contributions to mental and educational measurement, the great mass of Thorndike's discoveries can be brought under the broad head of learning, certainly a central problem in both psychology and education. His object in trying learning experiments on animals was partly that of tracing the evolution of intellect. But he soon saw that his results bore on the general psychology of learning; and in fact this line of investigation, which he inaugurated as a graduate student, has been taken up by many others and furnishes much of our current evidence on the learning process.

The principal conclusion which he



DR. EDWARD LEE THORNDIKE

PROFESSOR OF EDUCATIONAL PSYCHOLOGY, TEACHERS COLLEGE, COLUMBIA UNIVERSITY; ELECTED PRESIDENT OF THE AMERICAN ASSOCIATION

drew from his early experiments on animal learning, a much-debated conclusion which in the past few years he has placed on a stronger basis than ever by very ingenious experiments on human learning, is known as Thorndike's law of effect. An animal placed in a novel and puzzling situation tries a variety of responses till one succeeds, and if replaced time after time in the same situation gradually concentrates upon the successful response. The same course of events at a higher level is seen in human learning. Thorndike shows that one prime factor in fixing the successful response is the glow of satisfaction which it brings.

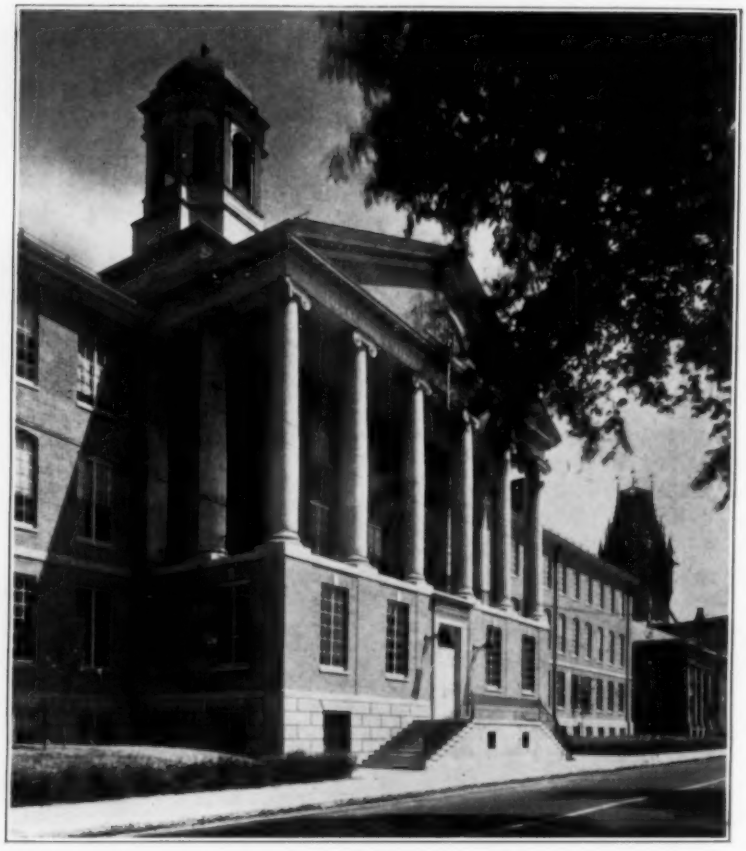
Another problem in learning to which he has devoted much attention goes by the name of "transfer." How much general improvement in memory, in keen observation or in reasoning is to be expected from practise in specific types of memory or observation or reasoning? How far does practise in geometry make one a good reasoner in law? Thorndike's early experiments indicated that the amount of transfer was small, and he applied this finding to education against the then dominant doctrine of formal discipline or faculty training. In recent years extensive experiments on the after-effects of high-school subjects have led him to the conclusion that the only justification for including any subject in the curriculum is the intrinsic value of its subject-matter to the student. A good student will gain from any study which he can take seriously. "When the good thinkers studied Greek and Latin, these studies seemed to make good thinking. Now that the good thinkers study physics and trigonometry, these seem to make good thinkers. If the abler pupils should all study physical education and dramatic art, these subjects would seem to make good thinkers. These were, indeed, a large fraction of the program of studies for the best thinkers the world has produced, the Athenian Greeks."

As these few high points in his work would indicate, Thorndike has always been a center of controversy. He is a first-class controversialist because of his unfailing good temper. He is not, however, primarily a controversialist, but a scientific worker, willing to take any amount of trouble and to go into any amount of detail to establish the truth on a worth-while problem. His painstaking analyses of the pupil's difficulties in such subjects as reading, arithmetic and algebra rank high among the many contributions which have made him a leader in the current effort to improve our traditional educational practise.

R. S. Woodworth
Columbia University

THE BOSTON MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A young scientist, attending the American Association for the Advancement of Science meetings for his first time, might be confused by the many programs given in widely separated buildings. Those of us who for a third of a century have journeyed to these mid-winter meetings, held in different parts of North America, were pleased that the Boston local committee had planned so well to care for the multitude of interests inherent in and associated with this largest of all science associations. The sudden drop to almost record low temperatures did not seriously interfere with the efficient working of the organizational plans, and a decidedly successful series of meetings was enjoyed by thousands of scientific workers. The official program of more than 150 pages

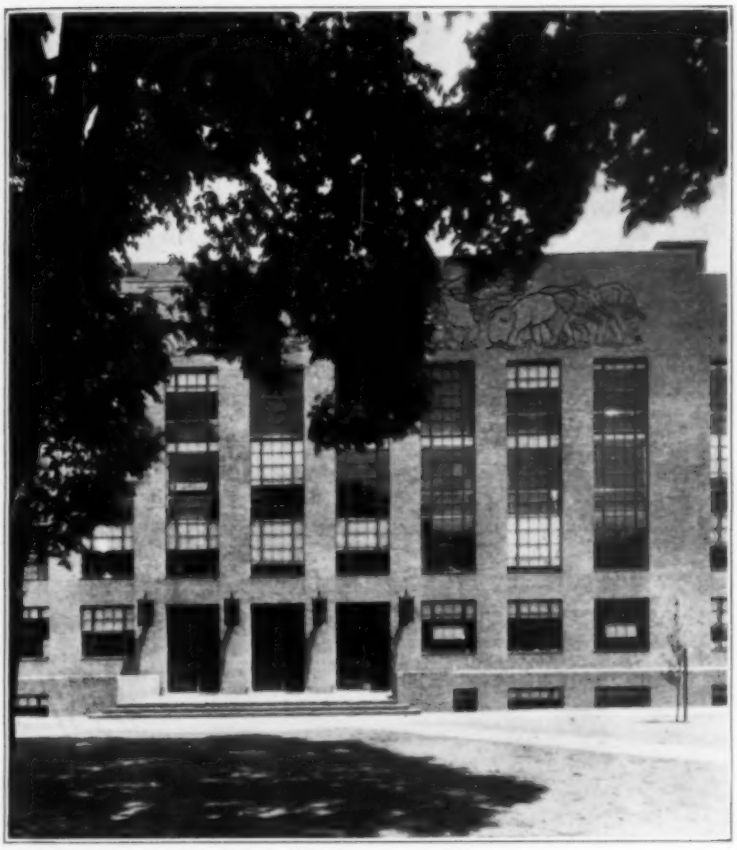


THE MALLINCKRODT CHEMICAL LABORATORY OF HARVARD UNIVERSITY

merely lists the topics that were considered. These topics are the captions of research papers that cover the whole range of scientific endeavors. Obviously, this brief account can do no more than mention a few of the many significant and more general features.

At the opening session on the evening of December 27 Dr. John J. Abel, the retiring president, gave an address on "Poisons and Disease" before a large audience in the Grand Ballroom of the Hotel Statler. President Henry Norris Russell, research professor of astronomy at Princeton University, presided and members of the association were welcomed to Boston by Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, and Dr. Harlow Shapley, director of the Harvard College Observatory. At the close of the program the audience and speakers adjourned to the Foyer, where a general reception was held.

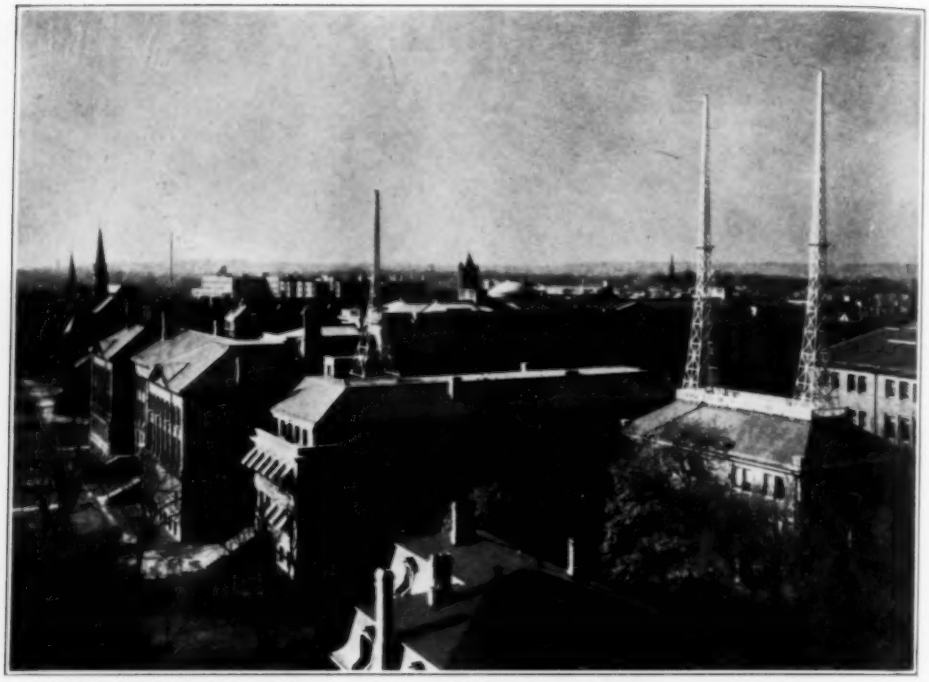
A member of the President's cabinet honored the association by addressing it. Secretary of Agriculture Henry A. Wallace spoke before the entire association on "The Social Advantages and Disadvantages of the Engineering-Scientific Approach to Civilization." It was a fundamental address, the merest suggestion of which can be given by quotations from remarks made near the opening and closing of Mr. Wallace's discussion. In referring to Spengler's



ENTRANCE TO THE BIOLOGICAL LABORATORIES OF HARVARD UNIVERSITY

philosophy of youth, middle age, then decay of nations, Mr. Wallace said: "According to this analysis, a civilization takes its origin in a profound, but as yet unexpressed new attitude on the part of a virile, agricultural people toward the universe. This profound, original feeling gives the bias to subsequent events throughout the life of the civilization. First, it manifests itself in great cathedrals and sculpture, next in painting, literature and music, followed by science, mechanics and wealth, and finally it manifests itself in dissolution, which comes because of a lack of faith in the worth-whileness of the original attitude toward the universe and because of disgust with the material results which have finally been inspired by that attitude. According to this analysis we have now come to the late fall, the eventide of this civilization, and the coming of the engineer is like the coming of Indian summer in late October just before the cold and dreary days of winter."

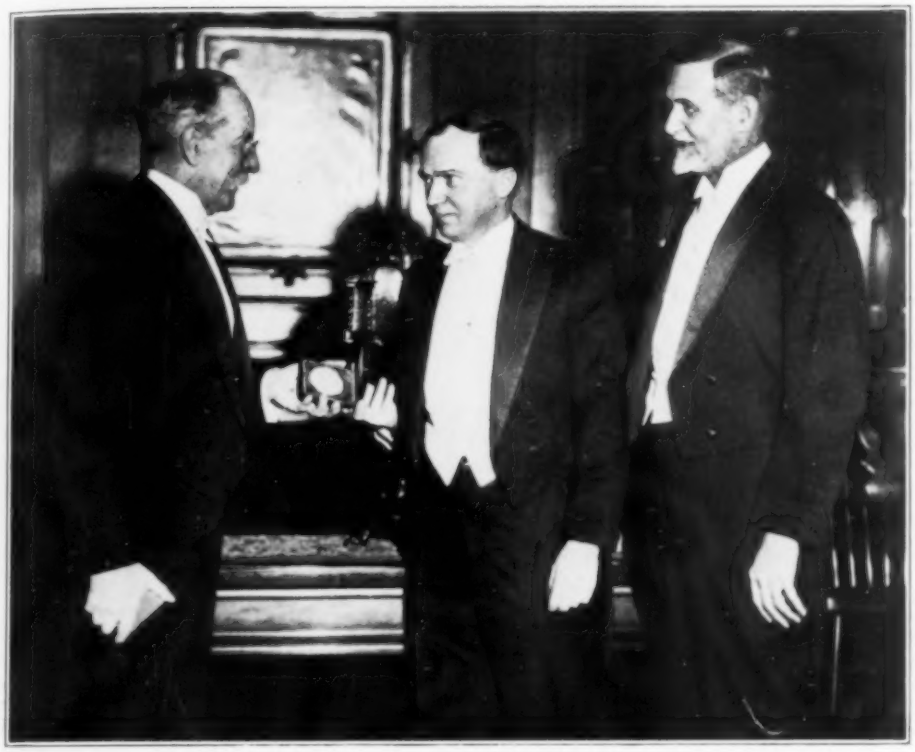
Then, after a clear and vigorous analysis of the factors involved in the problem, Mr. Wallace closed with: ". . . we wish a wider and better controlled use of engineering and science to the end that men may have a much higher percentage of his energy left over to enjoy the things which are non-material and non-economic, and I would include in this not only music, painting, litera-



THE JEFFERSON PHYSICAL LABORATORY AND THE CRUFT HIGH TENSION LABORATORY OF HARVARD UNIVERSITY

ture and sport for sport's sake, but I would particularly include the idle curiosity of the scientist himself. Even the most enthusiastic engineers and scientists should be heartily desirous of bending their talents to serve these higher human ends. If the social will does not recognize these ends, at this

THE GEORGE EASTMAN RESEARCH LABORATORIES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY



THE AWARD OF THE RUMFORD MEDAL TO DR. SHAPLEY

BY THE ACADEMY OF ARTS AND SCIENCES FOR HIS "RESEARCHES ON THE LUMINOSITY OF STARS AND GALAXIES." THE PRESENTATION OF THE MEDAL WAS MADE AT A JOINT MEETING OF THE AMERICAN ASSOCIATION AND THE ACADEMY AFTER WHICH DR. SHAPLEY ADDRESSED THE GATHERING ON "THE ANATOMY OF A DISORDERED UNIVERSE." IN THE PHOTOGRAPH ARE PROFESSOR A. E. KENNELLY, CHAIRMAN OF THE RUMFORD MEDAL COMMITTEE; DR. HARLOW SHAPLEY, AND PROFESSOR GEORGE H. PARKER, PRESIDENT OF THE ACADEMY.

particular stage in history, there is grave danger that Spengler may be proved right, after all, and a thousand years hence a new civilization will be budding forth after this one has long laid fallow in a relative Middle Ages." Secretary Wallace's address is published in full in *Science* for January 5, 1934.

Each year, by means of an annual gift from an unannounced donor, the association offers a prize of $1,000 for a conspicuous piece of research reported during the annual meetings. The various sections are expected to decide what papers, if any, of those presented in their sections are worthy of consideration by the association's committee on awards. That committee carefully considers the papers thus recommended to it. This year's prize was voted to Dr. Reuben L. Kahn, of the University of Michigan, in recognition of his discovery of the protective resistance of tissues against disease infection. Dr. Kahn's researches showed that the immunity of the skin is far more resistant, even ten times, than that of the blood, which has previously been regarded as containing the elements that are resistant to disease. The tissues of muscles and of certain epithelial tissues are also shown to possess this protective quality. We have

previously regarded the phagocytes and so-called antibodies of the blood as the chief agents of protection against recurring disease. Such far-reaching discoveries as announced by Dr. Kahn would seem to necessitate many important changes in existent ideas regarding the nature of immunity and the treatment of certain disease. As one of many results of Dr. Kahn's reports, the concept of "antibodies" in the blood and the relations of the blood to protection against disease seems to be in for scrutinizing restudy.

An occurrence of special interest to the writer was the meeting of teachers of the natural sciences, chiefly those engaged in secondary and elementary schools, and teacher-training institutions. The program had been arranged, under instructions from the council of the association by the Committee on the Place of Science in Education. It was thought that many teachers of science might wish to meet during the period of meetings of those who are engaged in research in the various aspects of science. About 125 representatives of at least fifteen science teachers' associations and individual science teachers attended. At the well-attended luncheon, Dr. Merriam spoke on "The Influence of Science on the One Who Studies It." The day's program elicited the request that the Committee on the Place of Science in Education shall prepare another one-day program for science teachers, this to be given in Pittsburgh during next year's meetings. At the request of the chairman of the committee, a cooperating committee of those present was decided upon. Dr. H. A. Carpenter and Dr. W. L. Eikenberry were named on that committee, and others are to be added. This committee, in cooperation with the Committee on the Place of Science in Education, will undertake to prepare the proposed Pittsburgh program.

The newly elected president of the association is Professor Edward Lee Thorndike, of Teachers College, Columbia University. Dr. Thorndike, not yet sixty years of age, has long been recognized as America's foremost student of application to education of the results of experimental psychology. The late Dr. Charles William Eliot was the last president elected to represent education. Dr. Thorndike not only represents education, which is Section Q, but has been a leading contributor to research in psychology, which is Section I. He surely is a worthy representative of IQ, and doubtless his election has the wide approval of educators, psychologists and scientists in general.

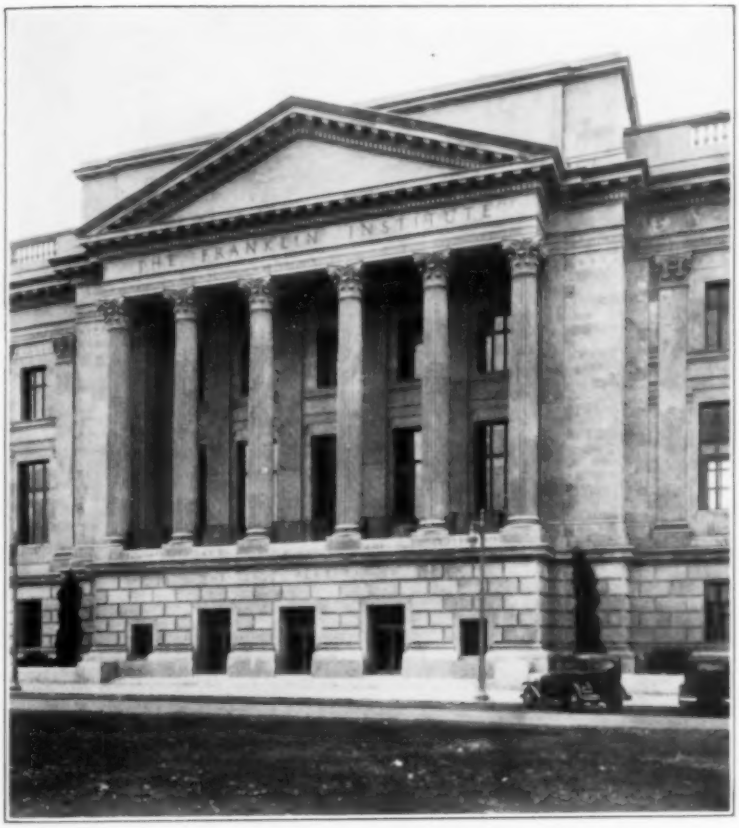
OTIS W. CALDWELL

THE FELS PLANETARIUM OF THE FRANKLIN INSTITUTE

FORMING part of the new building of the Benjamin Franklin Memorial and The Franklin Institute, in Philadelphia, the Fels Planetarium is now open to visitors 31 times a week. On December 5, the planetarium, as well as the rest of the building, was opened to the donors to the Benjamin Franklin Memorial fund, from which the building was erected. The opening of the other sections to the general public will follow in the immediate future.

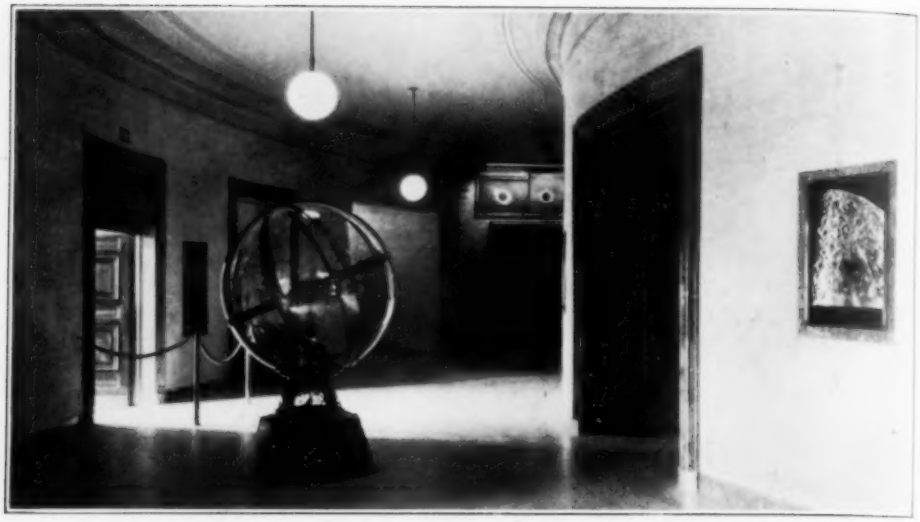
The building is located at Logan Circle, about half a mile from City Hall, and the site occupies an entire block, with an area of four and a half acres. A little less than half of the entire structure has now been erected, including all the east and north façades, each about 370 feet long. The main entrance is on the east, and an impressive flight of granite steps leads through a portico into a large rotunda, which will eventually contain a heroic statue of Benjamin Franklin by James E. Fraser.

On the north side is the Fels Plane-



THE ENTRANCE TO THE FELS PLANETARIUM

tarium, with its own entrance on the ground floor. Entering a curved lobby, with terrazzo floor and travertine walls, a number of transparencies of astronomical photographs, made at the Yerkes and Mt. Wilson Observatories, are seen. On one ground-glass screen is shown an image of the sun, formed by a coelostat telescope, with a lens on the roof, 85 feet above. On another screen the phenomena of partial, annular and total eclipses of the sun are reproduced, by means of a specially designed apparatus. At the eastern end of the lobby is a doorway, leading to a lecture hall, and above is a triptych of three paintings by Howard Russell Butler of the total eclipses of 1918, 1923 and 1925. At the end of a corridor on the west side of the planetarium chamber is a globe, also painted by Mr. Butler, representing the appearance of the earth from outer space. Viewing it from one end of the corridor, the museum visitor can see the earth as it would look if viewed from the distance of the moon. In the center of the lobby, just before the main door to the planetarium chamber, is a large orrery, made by Michael Sendtner, of Munich. This is a glass globe, five feet in diameter, on which are painted a number of the brighter stars and the constellation names. Inside are shown the sun and the planets out to Neptune, each rotating on its axis, provided with its satellites and revolving in its orbit.



THE FOYER OF THE FELS PLANETARIUM

SHOWING THE SENDTNER ORRERY, ONE OF THE TRANSPARENCIES AND PART OF THE GROUP OF ECLIPSE PAINTINGS.

Entering the planetarium chamber, one sees the Zeiss instrument in the center. Arranged in concentric circles around it are 500 chairs. The dome overhead, 20 meters in diameter, is made of sheets of stainless iron, each curved to the proper radius. These sheets are perforated with holes 1/16th inch in

THE PLANETARIUM CHAMBER SHOWING THE INSTRUMENT IN POSITION

VIEWING THE PLANETARIUM INSTRUMENT

LEFT TO RIGHT: DR. HOWARD MCCLENAHAN, SECRETARY OF THE FRANKLIN INSTITUTE AND DIRECTOR OF THE MUSEUM; SAMUEL FELS, THE DONOR; DR. JAMES STOKLEY, ASSOCIATE DIRECTOR FOR ASTRONOMY.

diameter, and 1/8th inch between centers. The purpose of these holes is to permit the sound of the lecturer's voice to penetrate without interference. A large part of the back wall is covered with padding of sound absorbent material, and thus objectionable echoes are completely suppressed. The inside of the dome, on which the images of the stars and planets are projected, is painted white, with a special paint giving very high reflectivity. This is the first planetarium dome to be so constructed, as all the previous ones in America and in Europe have fabric projection surfaces, which are subject to many disadvantages. When soiled, the metal dome can be cleaned, and a fresh coat of paint will restore it to its original whiteness. The paint is sprayed on, and this prevents filling of the holes, with consequent deterioration of the acoustic properties.

The formal opening of the Fels Planetarium took place on November 1, 1933, at 3:30 P. M., before a distinguished audience of invited guests.

Public demonstrations are being given every day, including Sunday, in the afternoon and evening. An additional public demonstration is given at 11:00 A. M. on Saturday. Each weekday at 10:30 and Saturday at 9:30 A. M., special demonstrations are given for the

school children of Philadelphia, who are admitted without charge. A special series for college students in astronomy, to accompany their courses, is being given.

Because so many phenomena can be shown with the planetarium, it is not possible to include them all in a single demonstration. Therefore, the subjects of the lectures will be changed monthly, beginning in January. Lectures are given by the writer and his assistant, Mr. Wagner Schlesinger, as well as by a staff of part-time demonstrators: Professor William H. Barton, Jr., director of the Hyatt Observatory of Pennsylvania Military College; Dr. William L. Fisher, assistant curator of the Commercial Museum; Dr. John H. Pitman, of Sproul Observatory, Swarthmore College, and Mr. A. Clyde Schock, the Philadelphia High School.

On an upper floor is the observatory and the astronomical exhibit hall. The principal instruments are a 24-inch reflecting telescope, made by J. W. Fecker, of Pittsburgh, and a 10-inch refractor, by Carl Zeiss, Jena. The latter is the first of its kind in the United States, as it is of the Urania type of mounting, developed at the Zeiss works especially for public observatories. The tube is balanced close to the eye end, and as a result the eyepiece moves through a much smaller range of height above the floor than with the conventional mountings. Thus, it is unnecessary for the observer to climb a high ladder when the telescope is pointed near the horizon. The entire roof above the telescopes slides back, making an opening 22 by 40 feet. This is also of great advantage for a public observatory, as the visitors can see the entire sky, and not a narrow strip, which is visible through the slot in the usual dome. The sliding roof is of steel and glass, weighing twenty tons, and is moved by an electric motor.

In the exhibit room which leads to the observatory are numerous other astronomical exhibits. These include the telescope used by the Yale University Observatory, the oldest in the country, when it was first established in 1830, another by Merz and Mahler, used at the Philadelphia Central High School, beginning in 1839, a meridian circle and a heliometer, loaned by the Yale University Observatory, a synchronome clock, models of stars and planets, additional astronomical transparencies, a painting of the planet Mars as seen from Deimos, painted by Mr. Butler, and the famous orrery made by David Rittenhouse for the University of Pennsylvania in 1871. This historic instrument has been restored to its original condition in the institute's shops, where many of the models have been constructed.

JAMES STOKLEY
Associate Director for Astronomy
THE FRANKLIN INSTITUTE